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AND CARIBBEAN

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Abbreviations

AFOLU	Agriculture Forestry and Other Land Use
CAR	Regional Autonomous Corporation, <i>Corporación Autónoma Regional</i>
CCDR	Country Climate and Development Report
CCUS	Carbon Capture, Usage and Storage
CICC	Intersectoral Commission on Climate Change, <i>Comisión Intersectorial de Cambio Climático</i>
CSA	Climate-Smart Agriculture
DANE	National Administrative Department of Statistics, <i>Departamento Administrativo Nacional de Estadística</i>
DNP	National Planning Department, <i>Departamento Nacional de Planeación</i>
DRM	Disaster Risk Management
EM-DAT	International Disasters Database
EU	European Union
FDN	National Development Finance Agency, <i>Financiera de Desarrollo Nacional</i>
FINAGRO	Financing Fund for the Agriculture Sector, <i>Fondo para el financiamiento del sector agropecuario</i>
FINDETER	Territorial Development Bank, <i>Financiera de Desarrollo Territorial</i>
FONSUREC	Sustainability and Climate Resilience Fund, <i>Fondo para la Sustentabilidad y la Resiliencia Climática</i>
GCF	Green Climate Fund
GDP	Gross Domestic Product
GW	Gigawatt
GHG	Greenhouse Gas
HA	Hectare
HA/YR	Hectares per year
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies, <i>Instituto de Hidrología, Meteorología y Estudios Ambientales</i>
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPLC	Indigenous Peoples and Local Community

LTS	Long-Term Strategy
LULUCF	Land Use, Land-Use Change and Forestry
MADS	Ministry of Environment and Sustainable Development, <i>Ministerio de Ambiente y Desarrollo Sostenible</i>
MANAGE	Mitigation, Adaptation and New Technologies Applied General Equilibrium
MDB	Multilateral Development Bank
MRV	Monitoring, Reporting and Verification
MtCO₂e	Million Tons (t) of Carbon Dioxide (CO ₂) Equivalent (e)
NAMA	Nationally Appropriate Mitigation Action
NCRE	Non-Conventional Renewable Energy
NDB	National Development Bank
NDC	Nationally Determined Contribution
PPP	Public-Private Partnership
PIGCCS	Sectoral Integrated Climate Change Management Plan, <i>Plan Integral de Gestión de Cambio Climático Sectorial</i>
PIGCCT	Territorial Integrated Climate Change Management Plan, <i>Plan Integral de Gestión del Cambio Climático Territorial</i>
NDP	National Development Plan
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RNZP	Resilient Net Zero Pathway
SAM	Social Accounting Matrix
SISCLIMA	National Climate Change System, <i>Sistema Nacional de Cambio Climático</i>
SMEs	Small- and Medium-Sized Enterprises
tCO₂e	Tons (t) of Carbon Dioxide (CO ₂) Equivalent (e)
TFP	Total Factor Productivity
UNFCCC	United Nations Framework Convention on Climate Change
UNGRD	National Unit for Disaster Risk Management, <i>Unidad Nacional para la Gestión del Riesgo de Desastres</i>

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Executive Summary

As Colombia navigates a complex path toward a richer and more equitable future, the country faces three critical climate transitions. First, it will need to transit from a climate-vulnerable to a more climate-resilient economy. Second, guided by its Long-Term Climate Strategy (LTS) and strong legal framework, which place it among the climate-goal leaders of the Latin America region, the country will need to navigate a transition to a net zero greenhouse gas (GHG) emissions economy in the context of its stated goal for 2050. Third, in a world that will demand increasingly less of Colombia's primary exports—oil and coal—and more green products, it will need to engineer a transition in its economic model.

This Country Climate and Development Report (CCDR) explores the opportunities for, and challenges to, achieving Colombia's development goals and its ambitious climate commitments, as well as the complementarities between the two. It explores how climate change and climate action would affect the country's growth and development and, in turn, how growth and development challenges would affect the achievement of its climate ambitions. The CCDR also investigates complementarities—specifically, how climate action could help Colombia achieve its development objectives, capture opportunities, support a just and inclusive transition, and protect its economy against longer-term risks from climate change and from the world's transition toward net zero GHG emissions.

In spite of Colombia's considerable development progress since 1990, the country still faces four structural challenges, transformational action on which will determine its ability both to achieve its ambitious development goals and to navigate these climate transitions. First, Colombia's current economic model is characterized by low productivity in main sectors, and a predominant role of natural resources in exports. Second, Colombia remains one of the most unequal countries in the world, with low social mobility and wide disparities across regions. Third, Colombian institutions in both the public and private sectors—on aggregate and as compared to their peers—lack adequate managerial and implementation capabilities and, correspondingly, have limited ability to innovate. Fourth, Colombia is still pursuing lasting, inclusive peace based on the 2016 peace agreement, action on which will require extending security, infrastructure, and basic services to post-conflict areas. Outlining a detailed agenda for action around these structural challenges is beyond the scope of this CCDR, but it is critical to note that a lack of transformational action in these areas will raise the cost and reduce the likelihood of navigating the three climate transitions noted above.

Climate change complicates Colombia's development ambitions, and in the absence of adaptation, the projected climate impacts will affect poverty and growth. Colombia faces higher risks than comparator countries (Figure ES 1). Climate-related disasters have already been increasing in frequency over the last few decades, and climate projections suggest that, in the future, more people will be impacted by floods and landslides, sea levels will rise, and the number of very hot days will rise dramatically. These changes will result in costly damage to infrastructure, disruptions to electricity generation, human capital losses, impacts on human health and labor productivity, agricultural losses, and financial risks. Modeling conducted for this report suggests that, when damage to physical capital and productivity is considered, climate change will reduce GDP by between at least 1.5 percent and 2.5 percent by 2050 in the absence of investments in adaptation. Poor and vulnerable populations will be affected disproportionately, with household consumption falling more among the rural than the urban population, and wage losses twice as high for informal than for formal workers.

FIGURE ES 1. Colombia's faces higher risks than comparator countries

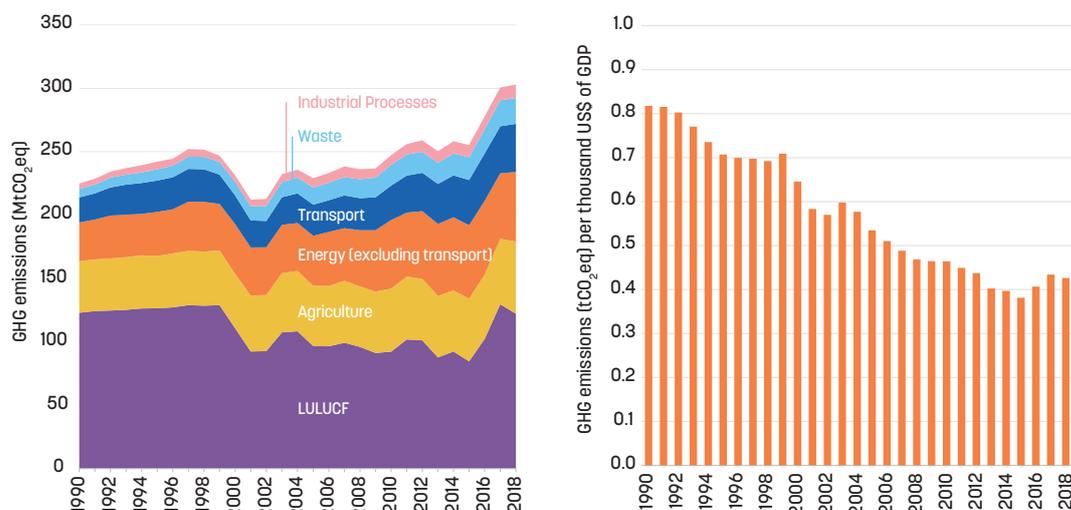


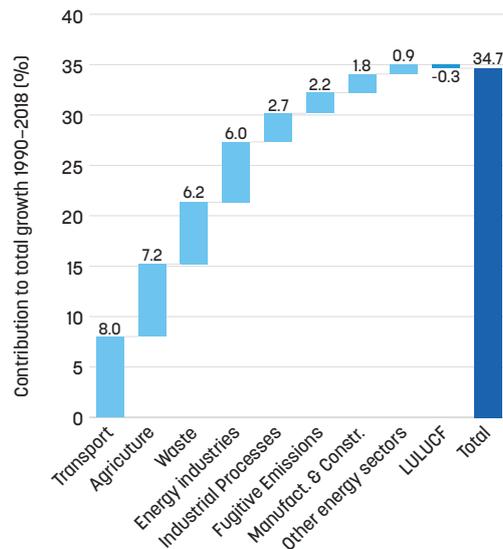
Source : Climate Analytics (2022); Kulp and Strauss (2019); Rentschler and Salhab (2020); UNDRR (2015); World Bank (2022a, 2022d, 2022e).

Equally concerning is the economic risk from global decarbonization. Although oil and mining contribute only about 5 percent of GDP, oil and coal dominate Colombia's exports. By 2050 lower global demand for oil and coal could cost Colombia about 10 percent of export receipts, up to 6 percent of government revenues, and up to 8.2 percent of GDP, in addition to the GDP losses from damage to physical capital, and lower productivity induced by climate change. Global decarbonization will act as a structural shock, with implications for the general conduct of macroeconomic and development policies.

Colombia's GHG emissions have decoupled in relative terms from economic growth but have nevertheless been increasing in absolute terms. Colombia is the 32nd-largest emitter out of 193 countries, and its GHG emissions account for 0.57 percent of global emissions. Its annual per capita GHG emissions of 5.4 tCO₂e place it 92nd in the world. Between 1990 and 2018, total GHG emissions grew 34.7 percent, propelled mainly by the transport, agriculture, waste, and energy sector. Between 2015 and 2018, this dynamic accelerated, driven primarily by emissions growth in the land use, land use change and forestry (LULUCF) sector. As of 2018, LULUCF represented 40 percent of GHG emissions, energy 31 percent (of which transport was 12.5 percent), and agriculture 19 percent (Figure ES 2).

FIGURE ES 2. Colombia's overall GHG emissions have been on the rise, even though the carbon intensity of the economy has been declining





Source: Government of Colombia (2022); World Bank (2022e).

In Colombia, there is no tradeoff between the climate and development agendas, and a resilient and net zero pathway can help Colombia achieve both its development and climate objectives.

Undertaking Colombia’s climate transitions would not alter the country’s development objectives and imperatives, but it would require broadening and deepening the actions needed to reach them. Colombia would embark on its climate transitions in a highly constrained external and fiscal environment and facing modest growth prospects. The current account deficit, for example, is already high. This means that global decarbonization will require that Colombia significantly expand other exports if it wants to preserve external sustainability without an economically painful contraction in imports. It also means that national savings will have to increase to create space for absorbing the additional investment needed for climate action. Irrespective of global decarbonization, Colombia will have to increase revenues to meet its development aspirations, such as improving the quality of public health and education, reducing poverty and inequality, and promoting productivity and economic diversification. Finally, higher growth would support the sustainability of macroeconomic policies. Decarbonization, future damage resulting from climate change, and the financing needs resulting from climate action add new urgency to the imperative to diversify exports and the economy in order to raise revenue and boost growth.

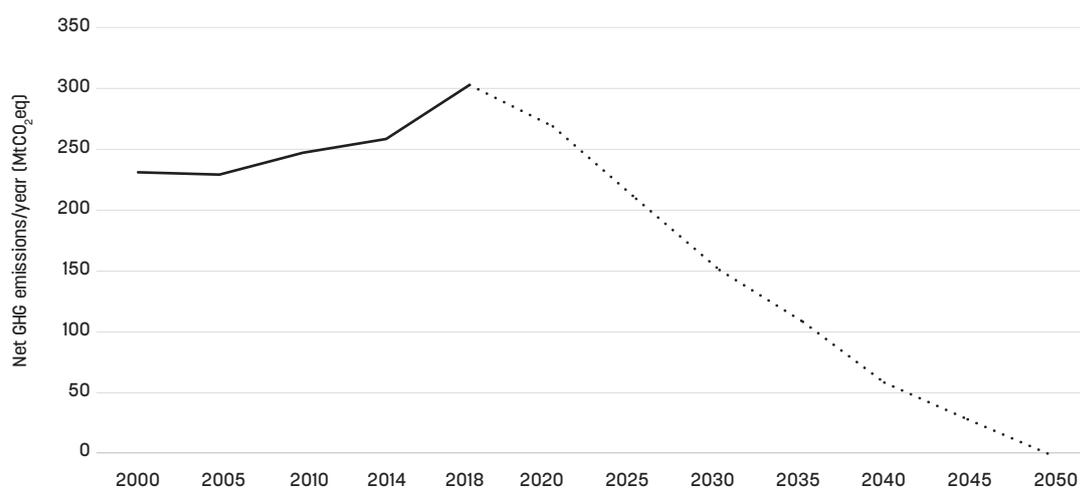
There are many possible pathways to align Colombia’s development and climate objectives, but three tenets can be followed to develop one such path. This report explores the feasibility, costs, and benefits of one such path that is —hereafter referred to as a Resilient Net Zero Pathway (RNZP) (Figure ES 3)— consistent with the country’s 2050 net zero and resilience pledge. The three tenets are as follows:

First, building resilience and adaptation requires an economy-wide approach and an emphasis on protecting the vulnerable. Building on Colombia’s existing strong performance in disaster risk management, the RNZP prioritizes adaptation in the transport, energy and building sectors, retaining the adaptive and mitigation capacity of landscapes by conserving and restoring forests, boosting climate-smart agriculture (CSA), and making social protection more adaptive.

Second, although it is in theory possible for Colombia to achieve its 2050 net zero emissions target, this would require a fundamental short-term improvement in emission trends. The RNZP modeled for this CCDD suggests that meeting carbon neutrality by 2050 will require a 2030 emissions target that is below the NDC’s 2030 mitigation target. This would imply dramatic mitigation action: Deforestation would need to be limited to 37,500 ha/year as early as 2024, sustainable livestock systems would need to be established at a rate of 2 million ha per year, and by 2030, some 5.6 million hectares of land would need to be restored. Additionally, 67 percent of public buses and 55 percent of cars would need to be electric (up from 0 in 2021), 20 percent of freight would need to be transported by rail (up from 7 percent in 2021), and renewable electricity generation would need to expand by 8 percent per year.

This improvement in emission trends would require a very intensive, short-term policy effort. To lay the groundwork for such accelerated implementation, including past 2030, Colombia would need to focus on several key areas. In the land use sector, it would entail expanding land administration, tenure, and rights in deforestation hotspots, increasing the effectiveness of law enforcement to rein in land grabbing, and reorienting agricultural support toward green innovation. In the transport sector, the priorities would be to encourage the uptake of zero-emission vehicles by expanding charging infrastructure and economic incentives, and implementing all mass transit, non-motorized and multimodal freight projects in the pipeline. In the energy sector, priorities are incentivizing the electrification of building energy use, and scaling up renewable electricity generation.

FIGURE ES 3. To achieve its 2050 net-zero goal, Colombia will need to reduce emissions by at least 3 percent per year



Source: Historical emissions (2000–2018): Government of Colombia (2022); modeled emissions (2020–2050): World Bank (2023e).

Third, Colombia will need to ensure a just transition in the context of national and global decarbonization, with an emphasis on protecting the most vulnerable and exposed populations. This particularly applies to coal and oil workers, whose jobs and surrounding local economies, respectively, will be at risk. It also applies to indigenous peoples and local communities in geographical areas of strategic importance for deforestation control.

The climate action required for Colombia to achieve its objectives will have substantial but not insurmountable costs, and these investments would also generate economic benefits. This CCDR estimates that an integrated package of investment to promote resilience and carbon neutrality by 2050 would require US\$92 billion (in 2023 present value) in additional investment relative to a baseline that does not include climate objectives (Table ES 1). These additional investments represent 1.2 percent of Colombia’s discounted cumulative GDP over 2030–2050. Such investments would propel a transformation in the way goods and services are produced, and reduce operating and maintenance costs, thus enabling the recovery of about one-third of the investment.

TABLE ES 1. Additional investment needs and economic costs in the RNZP (in US\$ billion)

	2023–2030	2031–2050
ENERGY (excluding transport)		
Additional investment: electricity generation	1	4
Additional investment: transmission	3	9
Additional investment: H2 generation	0	9
Additional investment: efficiency and electrification of buildings and industry	<+1	1
Additional investment: resilient housing	<+1	0
Other economic costs: drought operational losses	-2	0
Other economic costs: operational, exports and imports	>-1	7
Other economic costs: air pollution externality costs	0	>-1
Other economist costs: housing disaster losses	0	>-1
TRANSPORT		
Additional investment: infrastructure (mass transit, freight and non-motorized)	11	20
Additional investment: resilient roads	<+1	0
Additional investment: fleet (trucks, cars and buses)	-1	-12
Other economist cost: energy and maintenance	-3	-11
Other economic costs: cost of disruptions	>-1	>-1
Other economic costs: air and noise pollution, congestion, and road fatalities	-1	-22
AGRICULTURE AND FOREST LANDSCAPES		
Additional investment: climate-smart agriculture, livestock, forestry, and conservation	19	17
Additional investment: resilient agriculture and wildfire protection	<+1	0
Other economic costs: productivity and ecosystem services	-2	-39
Other economic costs: operational and maintenance costs	-1	-18
Other economic costs: disaster losses	-1	-4
WASTE		
Additional investment: infrastructure	4	3
Other economic costs: energy and materials	>-1	-2
TOTAL INVESTMENTS AND ECONOMIC COSTS IN THESE SECTORS		
Net economic cost	30	-37
	Includes: additional investment	40
		52

Source: World Bank (2023e).

Note: All amounts are discounted using a 6 percent discount rate.

Such ambitious climate action would also generate overall economic benefits, creating jobs and reducing inequality. Increasing climate resilience and decarbonizing would reduce air pollution, traffic congestion, and vulnerability to fluctuations in global energy markets, generating US\$7 billion in economic benefits to the economy by 2050: in the short-term (2023–2030), a net economic cost of US\$30 billion would result, offset by a long-term (2030–2050) net gain of US\$37 billion. Modeling for this report suggests that the appropriate additional climate investment could increase GDP by up to 2 percent by 2050, compared to a scenario without this investment. Household consumption would also increase slightly—more so for poorer households than for wealthier ones—such that the investments would contribute to reducing Colombia’s high baseline inequality.

Additional financing needs from the private and public sectors will amount to between 1.1 and 1.5 percent of GDP (Table ES 2). This would constitute a level of climate investment 5 to 7 times what has been mobilized so far. Additional public climate investment would amount to between 0.2 and 0.4 percent of GDP. This compares to an annual public investment budget that averaged 4.2 percent of GDP between 2018 and 2022. Increasing carbon prices to curb emissions could provide enough resources to pay for this investment. However, as global demand for oil and coal declines, so will the related government revenues. In addition, because carbon prices

will increase energy prices and, indirectly, prices of goods and services, the government would need to put in place transfers to compensate the most vulnerable for losses. To make up for lost revenues and the cost of additional transfers, other taxes would have to go up, and spending would need to become more efficient. Measures to boost growth would also help create fiscal space to absorb the costs.

Under the right conditions, on average about 80 percent of the required investment could come from the private sector between 2023 and 2050. The ability to mobilize private capital depends on several factors, in particular, macroeconomic stability, sector regulations, incentive frameworks, the evolution of climate finance, and the level of long-term, patient capital. Action on two fronts will be required. To attract private capital, Colombia should leverage its expertise in the use of public-private partnerships (PPPs) in the infrastructure sector and ensure that a robust regulatory framework and economic incentives are in place to accelerate the use of climate-focused PPPs by, among other things, implementing (i) systematic screening for climate risk in PPP applications; (ii) a robust project pipeline with climate risk allocation well balanced between public and private stakeholders; and (iii) the development of new financial products to overcome market barriers, including blended finance vehicles. Additionally, the private sector's capacity to innovate needs to be boosted by scaling up enterprise support programs that promote productivity and innovation. Finally, the adoption of new technologies and skills—especially from abroad, where it is expected that the frontier of green technological innovation will be—needs to be facilitated.

To spur private climate action, Colombia will need to continue and deepen its efforts to mobilize private finance. Critical areas for action include (i) leveraging the green taxonomy and green bond frameworks to scale up climate finance for strategic areas, such as CSA and low-carbon infrastructure; (ii) improving existing metrics and pushing for more transparency on assessing and disclosing climate-related financial risks in investment portfolios; (iii) promoting the economy-wide disclosure of climate-related performance of financial institutions using international standards such as the Sustainability Disclosure Standard; (iv) pushing financing institutions to define climate-related governance, strategy, opportunities, risk management, and metrics; (v) developing innovative, new, climate finance instruments, including de-risking structures, sustainability-linked finance products, corporate loans, project finance loans, revolving credit facilities, and derivatives that allow borrowers to meet the different risk/return profiles of potential investors as well as the varying capacity of firms to tap into financial markets; and (vi) developing carbon markets. These efforts would help create a level playing field on which the private sector can best contribute its innovation and investment potential toward Colombia's RZNP.

TABLE ES 2. An illustrative pathway for funding Colombia's climate transition costs

	Range of additional financing needs (in percent of GDP)	
	2023–2030	2031–2050
Total: public + private	1.5	1.1
<i>Public sector (= A - B)</i>	<i>0.4</i>	<i>0.2</i>
(A) Climate transition costs	1.7	1.9
Revenue losses from oil and coal	1.2	1.6
Additional climate investment	0.4	0.2
Adaptative social security	0.1	0.1
(B) Resources from revenue shifts and spending reductions (net)	1.3	1.7
Carbon pricing	0.7	0.7
Higher taxes	0.3	0.7
Increase efficiency of spending and subsidies	0.4	0.4
Compensation for the poor	-0.1	-0.1
<i>Private sector (= C)</i>	<i>1.1</i>	<i>0.9</i>
(C) Additional climate investment	1.1	0.9

Source: Authors' estimates.

For Colombia to reach its climate goals, time is of the essence, and investment therefore needs to be frontloaded. About half of investment will need to happen before 2030. Although the public sector has the capacity to pay for part of the investment by raising revenues, increased private sector investment will also require long-term financing, because it is projected that most of the returns will materialize after 2030. Mobilizing public and private investment will require action on many fronts—from tapping bilateral, multilateral, and private sources of climate finance, to repurposing subsidies that currently increase GHG emissions by directing public financing toward climate-smart investments.

Although the overall economic impact of pursuing development and climate objectives is expected to be positive, the transitions would create challenges for exposed sectors. The CCDR predicts that GDP will grow under the RNZP relative to a baseline with no climate action, thanks to the large investments required, increased energy efficiency, increased productivity, and reduced operational and maintenance costs. Meeting Colombia's 2030 mitigation goal has the potential to add 347,000 jobs (or 1.6 percent of the 2022 employment level) to the economy between 2023 and 2030, and adaptation investments would create further jobs. Nonetheless, Colombia's decarbonization pathway will create some winners and losers. In particular, jobs are expected to be shed in the coal and oil industries, while other sectors are expected to add jobs.

Achieving Colombia's climate and development objectives simultaneously will require a set of targeted sectoral policy and investment packages to underpin sectoral milestones on the road to net-zero by 2050:

- 1. Sustainable and Productive Landscapes for Climate Adaptation and Mitigation.** With land use, land use change, forestry, and agriculture accounting for 59 percent of Colombia's GHG emissions, Colombia's land use sectors are central to climate action. Intact landscapes are also crucial for the provision of ecosystem services that underpin Colombia's climate resilience. Climate change is expected to further depress already low productivity in agriculture through a combination of heat, extreme weather events, water scarcity, and flooding. Deforestation is the primary driver of emissions in the land use sector and, without drastically reducing deforestation and scaling up restoration and afforestation, achieving Colombia's 2030 and 2050 climate commitments will remain out of reach. The following priorities emerge to achieve a transformational shift from extractive to sustainable and productive land use, with a focus on deforestation control and CSA and livestock systems:
 - To reduce land use emissions and to retain and rebuild the adaptive capacity of landscapes in line with Colombia's mitigation goals, deforestation would need to rapidly be curtailed to no more than 37,500 hectares per year (ha/year), and by 2030, 25,000 ha would need to be reforested, 620,000 ha afforested, and 5.8 million ha of land restored.** Land use—mostly deforestation control, restoration, and afforestation—will need to make up 52 percent of Colombia's emission reductions by 2030 and 44 percent by 2050. Achieving this will require institutional and policy reforms that, one, give the national government greater control and deeper reach into the national territory, and two, streamline policymaking and implementation across institutions and layers of government. This would also facilitate actions on multiple fronts that are required to monitor and curb land use change. Focusing on deforestation control, priorities include (i) making law enforcement more effective; (ii) bringing land grabbing in check, focusing on the areas of highest deforestation, (iii) investing at scale in sustainable production and restoration in deforestation hotspots along the agricultural frontier and in environmentally strategic areas; (iv) strengthening the enabling environment for investments in sustainable and resilient land use, including by creating incentives for better decentralized deforestation control performance, and (v) improving institutional and community governance, especially for indigenous peoples and local communities.
 - To reduce emissions from agriculture in line with Colombia's climate goals, by 2030, 16.3 million ha of livestock systems would need to be made sustainable, the expansion of pasture areas and herd growth would need to decline, and an additional 3.2 million ha of agricultural land would need to be sustainably intensified.** The livestock sector, which accounts for 14.8 percent of Colombia's GHG emissions, occupies 91 percent of Colombia's agricultural land

and has major impacts on the adaptive capacity of landscapes. It will be important for both the agriculture sector as a whole, and the livestock sector in particular, to become more climate-smart at scale. This will involve (i) repurposing agricultural support toward promoting green innovation; (ii) strengthening the agricultural innovation system to mainstream CSA and livestock innovation technologies and practices; and (iii) fostering financial innovation to spur technology adoption and to improve risk management. In addition, land administration and law enforcement are important to prevent increased agricultural productivity leading to greater deforestation.

2. Low-Carbon and Resilient Infrastructure. The infrastructure sector is a second critical pillar in the climate transition, from both an adaptation and mitigation perspective. Colombia's infrastructure is highly vulnerable to climate change, with significant effects on the economy and livelihoods. Energy also accounts for 31 percent of Colombia's GHG emissions, with transport on its own accounting for 12.5 percent. Accelerating investment in low-carbon and resilient infrastructure will generate important economy-wide and poverty co-benefits by (i) addressing overall infrastructure gaps; (ii) enhancing economic productivity and growth through improved connectivity and access to affordable, reliable, and resilient infrastructure services; (iii) reducing air and noise pollution; and (iv) reducing road congestion and road accidents. This CCDR outlines a priority agenda for action on low-carbon and resilient infrastructure in the transport, energy, and water sectors.

- **To reduce emissions from energy and develop a resilient grid, among others, renewable electricity needs to reach 24 gigawatts (GW) and green hydrogen at least 2 percent of industrial energy by 2030.** Critical areas for action include (i) developing a climate-resilient electricity generation, transmission, and distribution system; (ii) aligning electricity sector policies; planning, and regulations with decarbonization objectives, (iii) increasing the share of renewable power generation; (iv) increasing the electrification of end uses; (v) increasing energy efficiency uptake; and (vi) developing regulations for the production and use of low-carbon hydrogen.
- **In the transport sector, by 2030, among others, 67 percent of all public transport and 55 percent of cars would need to be electric, cycling lanes would need to cover 1,750 kilometers (km), and 20 percent of freight would need to be transported by rail.** The priorities include (i) invest in climate-resilient rural roads in lagging regions; (ii) strengthen regulatory framework and use of climate finance products designed to incentivize private investment in adaptation of primary roads; (iii) electrifying public transport systems; (iv) improving the risk allocation and bankability of concession contracts in urban transport; (v) continuing the modal shift toward mass transit and active transportation; (vi) implementing multimodal freight transport projects; and (vii) developing a policy and investment program for low-carbon trucking.
- **In the water sector,** the priorities include (i) increasing adaptive capacity by investing in water supply, sanitation, and irrigation in lagging regions; and (ii) increasing the baseline resilience of service providers by reducing fragmentation in water supply and sanitation services.

3. A People-Centered and Just Transition. An equitable and just transition is a precondition for ensuring that the actions proposed under the framework of Colombia's climate commitments maximize its development potential and avoid a deepening of inequalities. Ambitious climate action, in the aggregate, represents a significant opportunity to yield economic benefits, create jobs, and reduce poverty, vulnerability, and inequality. Nonetheless, the proposed agenda for climate action in Colombia's NDC—and the exogenous factors that are likely to impact demand for Colombian exports of oil and coal—have the potential to adversely impact particular populations. These impacts can manifest themselves, among others, as (i) job losses in the extractive industries; (ii) reduced royalty revenues for regions in which extractive industries are located; and (iii) reduced consumption because of higher fuel and energy prices from the elimination of fuel subsidies and scaling up of carbon pricing. In addition, climate-related hazards pose risks to vulnerable populations. This report recommends a priority program for action to support a people-centered and just transition:

- **On social protection:** To buffet the impacts of climate-related events on the most vulnerable, Colombia should make its social protection system more adaptive by (i) raising the coverage and amount of benefits; (ii) adapt productive inclusion programs to include climate resilience measures; (iii) innovating within the delivery chain of social protection programs (from targeting to case management); (iv) creating counter-cyclical financing instruments and redirecting resources toward areas prone to climate disaster risk, where the poorest tend to be concentrated; (v) upgrading early-warning systems and the interoperability between the social registry and the DRM registry; and (vi) strengthening inter-institutional coordination between the social protection and DRM sectors.
- **On facilitating job transitions for workers in exposed sectors:** To cushion the impacts of national and global decarbonization on the fossil fuel sector, Colombia should develop job transition and economic development programs to include (i) implementing training and reskilling programs; (ii) introducing compensatory transfers and insurance programs; (iii) designing programs to facilitate worker reallocation; (iv) promoting innovation in green technologies, and (v) incentivizing and facilitating links between firms and research institutions. To inform the job transition programs, social and economic analyses of coal phase-out diversification should be pursued in vulnerable departments such as Cesar, Boyacá, and La Guajira.

The transformation needed to realize Colombia's climate ambition will require strengthened coordination, institutions, and capacity. Despite the robust policy, strategy, and institutional architecture for climate change that Colombia has developed, effective climate action continues to be held back by coordination and institutional factors. These include (i) rigidities in modes of inter-institutional cooperation and coordination; (ii) persistent inconsistencies in mitigation policies across planning instruments and lagging implementation planning; (iii) limited capacity for implementing adaptation at subnational levels; and (iv) fragmented institutional frameworks in key sectors that are relevant to climate action, such as sustainable land use. To address these constraints, Colombia should:

- **On climate strategy implementation:** (i) improve coordination between national agencies to ensure climate policy alignment; (ii) improve collaboration mechanisms between the central and decentralized levels; (iii) develop a comprehensive program of measures to reach the NDC targets; (iv) create detailed implementation plans for all adaptation and mitigation actions with connected financing frameworks; and (v) monitor NDC and LTS achievement.
- **On the decentralized implementation of adaptation:** (i) issue technical guidance and build capacity to ensure quality across territorial planning instruments; (ii) mainstream adaptation into territorial planning; (iii) bolster coordination between the National Climate Change System (SISCLIMA) and the National System for Disaster Risk Management; (iv) strengthen subnational capacity for the implementation of adaptation measures; (v) conduct and/or update risk and vulnerability assessments to inform subnational government planning; (vi) develop guidelines and methodologies to aid subnational adaptation planning; and (vii) devise template projects for climate adaptation.

Ambitious climate and development action will require coordinated and transformational measures along multiple dimensions. On the fiscal front, Colombia would need to create fiscal space and hence (i) raise more revenues, with a focus on increasing the carbon price and extending its coverage while establishing compensatory payments to the poorest Colombians; (ii) phase out fuel subsidies as quickly as possible; and (iii) improve the efficiency of spending (for example, by rationalizing utility subsidies). On the structural front, Colombia will need to accelerate growth through enhanced productivity and to diversify its export base. It will also need to enable the absorption of the technology and capital goods needed for the climate transition.

Although the climate transitions will entail political economy challenges and social impacts, Colombia will be better off tackling them head-on than “kicking the can down the road” and leaving current political economy and social issues unresolved. Structural economic change will produce results over the medium and long term by, for example, drawing capital to urban areas and away from the deforestation

frontier. But to jump-start the urgent, short-term transformations required to meet Colombia's goals, this structural change needs to be complemented by economy-wide and sectoral interventions. Each of these interventions will face their own implementation, institutional, and political barriers, requiring significant departures from current trends, plans, and practices.

Colombia has a time-bound opportunity to set its economy on a more climate-resilient and low-carbon track. This will not be easy but it would yield economic benefits, boost productivity, and help preserve the country's outstanding biodiversity. This CCDR estimates that the total cost of the interventions needed to achieve these goals would be manageable. This is because its large hydropower base and significant potential for further renewable energy development result in a comparatively low-cost mitigation pathway; but also, because a successful transition will generate direct and indirect benefits that exceed the costs. This CCDR furthermore makes the case that the actions needed to accelerate Colombia's development are complementary—not antagonistic—to the actions needed for the climate transitions. In other words, switching to a growth model that hinges more on innovation, better managerial practices, more capable institutions, and higher productivity would spur growth and support export diversification, but this would, concurrently, also reduce the country's economic vulnerability to global decarbonization, foster the adoption of newer and greener technologies, and support a slowdown in deforestation.

Although the total cost would be manageable, this CCDR nevertheless recognizes that mobilizing the necessary funding will require deep changes in how the economy operates, together with a prominent role for the private sector. These changes are emphatically worth making. Success does not only mean reducing the impacts of climate change on Colombia's economy and people, meeting its net-zero commitment, and navigating a world in which fossil fuels are in significantly lower demand; it also means accelerating development.

Introduction

This CCDR examines the implications of climate change and climate action for Colombia's development objectives, priorities, and pathways. It identifies opportunities for Colombia to achieve both its development goals and its climate commitments through a coherent set of policies. It lays out a combination of sectoral and economy-wide policy reforms and targeted investments in near- and medium-term mitigation and adaptation measures designed to achieve more rapid, more inclusive, and greener development. The idea is to maximize synergies between climate and development objectives, while addressing tradeoffs among policy objectives and key transition challenges. The CCDR is structured in five sections:

- Section 1 focuses on Colombia's development context, including its priorities, its main economic challenges, the risks that climate change, disasters, and national and global decarbonization efforts create, and the opportunities that the climate transition opens.
- Section 2 outlines existing climate commitments and policies, including Colombia's Nationally Determined Contribution (NDC). It also includes an assessment of the institutional framework, policy coordination issues, and capacity constraints for implementation, particularly at the subnational level, for achieving Colombia's climate and development ambitions, and an assessment of Colombia's progress on private climate finance.
- Section 3 explores pathways to achieving resilience and decarbonization. Using Colombia's commitment to climate resilience and carbon neutrality by 2050 as a basis, the section includes deep dives into the challenges of, and opportunities for, achieving mitigation and adaptation goals that are associated with (i) sustainable and productive landscape management, and (ii) transport, energy, and water infrastructure. The section further explores the risks to an equitable and just transition and proposes concrete measures to enhance the resilience of potentially affected populations and communities. Lastly, it sets out a sample pathway for Colombia to achieve its resilient and net zero ambitions by 2050 and assesses the financial and economic costs and benefits of doing so.
- Section 4 explores the macroeconomic implications of the climate transition. It analyzes the constrained macro-fiscal environment and, within these parameters, explores alternatives to enhance fiscal capacity to fund the climate transition. It further assesses the current development model and proposes critical structural reforms and actions that would be required to strengthen Colombia's ability to achieve its climate transition ambitions. Finally, it proposes avenues for financing the transition.
- Section 5 concludes with an effort to prioritize the policy and investment packages and actions that ideally should be emphasized over the short and medium terms to enable Colombia to seize opportunities and reduce risks associated with climate change while achieving its development goals.

The CCDR was informed by existing and new analyses of development and climate action in Colombia conducted by the World Bank, its development partners, research institutions, and non-governmental organizations.

1. Colombia's climate and development challenges and opportunities

Main messages

- Colombia is an upper-middle-income country with significant development challenges, including reducing poverty and inequality, upgrading institutions, and sustaining peace.
 - Climate change poses a threat to Colombia's development by exacerbating inequality and poverty and through damage to physical capital and infrastructure, disruption of electricity generation, reduction of labor productivity and human capital, and losses in agriculture.
 - Given Colombia's status as a fossil fuel exporter, decarbonization of trading partners could have negative effects on employment, trade, and the fiscal balance through reduced demand and prices of fuel commodities.
 - Colombia is a regional leader on climate change ambition but its ability to achieve results may be limited by its current development model, with low productivity (especially in agriculture), weak capacity to control land use and deforestation, a growing motorization rate and insufficient transport alternatives, limited capacity to innovate, limited capacity in decentralized governments, limited fiscal space, high informality, and limited dynamism of financial markets.
-

1.1. Colombia faces significant climate and development challenges but has the prospect to fulfill its ambitions

Colombia is an upper-middle-income country, but although growth has been stable, one of its fundamental development challenges is lifting its growth potential. Between 2000 and 2019, Colombia enjoyed stable growth averaging 3.8 percent per year and made progress in reducing poverty and improving human development outcomes. While its growth performance allowed it to become an upper-middle-income country in 2008, this has been insufficient to ensure significant convergence with richer countries: income per capita has remained stable, at around 12 percent of that of the United States since 2000. Under current policies, prospects for future convergence are limited: potential growth has been on a declining trend since 2015 and is now around 3.2 percent. This is still too low to significantly increase income per capita and catch up with the living standards of other emerging market countries.

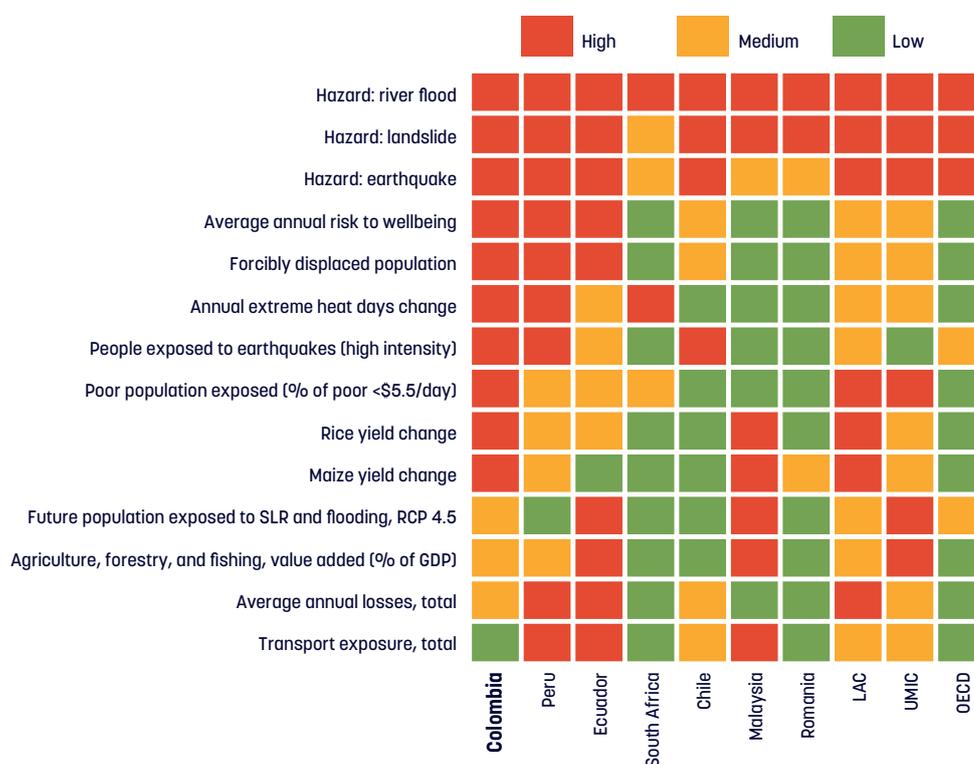
In addition to accelerating growth, three additional development imperatives stand out:

- » **Reducing poverty and inequality.** Colombia is one of the most unequal countries in the world, with very low social mobility and high spatial disparities (World Bank 2021b). Following a spike in 2020 due to the COVID-19 shock, the poverty rate has come down. Yet 39 percent of the population—more than in 2019—remain poor and poverty has increased in rural areas. Poverty and inequality are a missed opportunity to fully use the population's human capital potential and hence expand the economy (World Bank 2005).
- » **Upgrading institutions, at all levels and in all sectors.** For example, the managerial practices of Colombian firms compare poorly with those of other countries, translating into a limited ability to innovate (World Bank 2022h); about 60 percent of rural land is held without a formal property title, with negative effects on agricultural growth and productivity; financial markets do not cater to the needs of small businesses and low-income households; informality pervades the labor market and productive sectors, limiting economic agents' access to markets, information, and finance; and finally, governance underperforms compared to high-income countries in most dimensions (World Bank 2022h); in particular, governance challenges hinder key tasks such as deforestation control.

» **Sustaining peace.** Colombia has been mired in conflict for most of its modern history. Had the country been at peace since 1995, per capita income would be 50 percent higher today (World Bank 2015). The 2016 peace agreement opened space to address the country's other development constraints. An enduring resolution to the conflict and the implementation of the rural reform provisions of the 2016 peace agreement would attract investment, boost growth, and reduce poverty, particularly in those areas most affected by the conflict (World Bank 2022h).

At the same time, Colombia already faces significant climate challenges. Colombia is highly exposed to natural hazards. It scores high on 10 out of 14 different drivers of risk, which include different elements of exposure, vulnerability, risk, and future climate change impacts (Figure 1.1). It has one of the highest rates of disasters caused by natural and climate-induced hazards in Latin America,¹ with floods and landslides being the most prevalent and increasingly frequent hazards (World Bank 2021c). Exposure to climate risks is widespread: 47 percent of the territory face "high" or "very high" climate risks (IDEAM 2017), and 84 percent of Colombia's population and 86 percent of its assets are exposed to two or more natural hazards (Agwe et al. 2005; World Bank 2022c). According to MHCP (2021), disaster and climate risks represent by far Colombia's largest contingent liability, with a potential impact on economic activity of up to 4.4 percent of its GDP.

FIGURE 1.1. Colombia faces higher risks than comparator countries



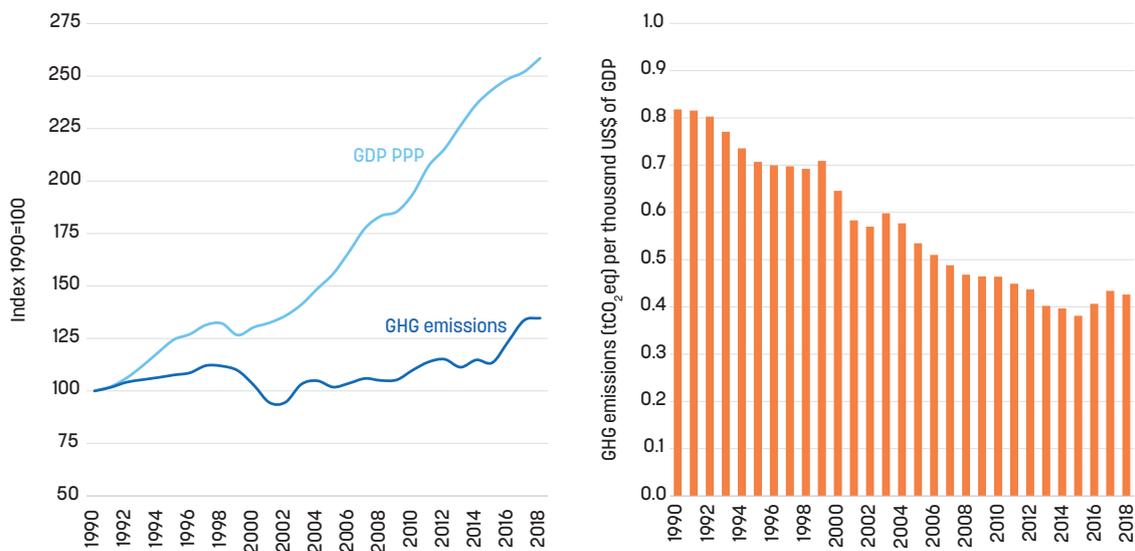
Source: Climate Analytics (2022); Kulp and Strauss (2019); Rentschler and Salhab (2020); UNDRR (2015); World Bank (2022a, 2022d, 2022e).
 Note: The indicators are a selection of drivers of risk. Countries are rated using a benchmark approach based on similar and aspirational countries. Countries in red (high risk) are in the upper tercile; those in yellow (medium risk) are in the middle tercile; and those in green (low risk) are in the lowest tercile.

Colombia's GHG emissions have been increasing over time. Colombia is the 32nd highest emitter out of 193 countries (Climate Watch 2021), and its GHG emissions account for 0.57 percent of global emissions. Its per capita GHG emissions of 5.4 tCO₂e place it 92nd in the world (Climate Watch 2021; World Bank 2022g). GHG emissions and economic growth have been relatively decoupling over time (Figure 1.2), in line with regional trends. This is in part due to energy efficiency gains in transport and industry, a decrease in the

¹ Colombia ranks 2nd in the Latin America region in the hazard and exposure category of the INFORM Risk Index (European Commission 2022).

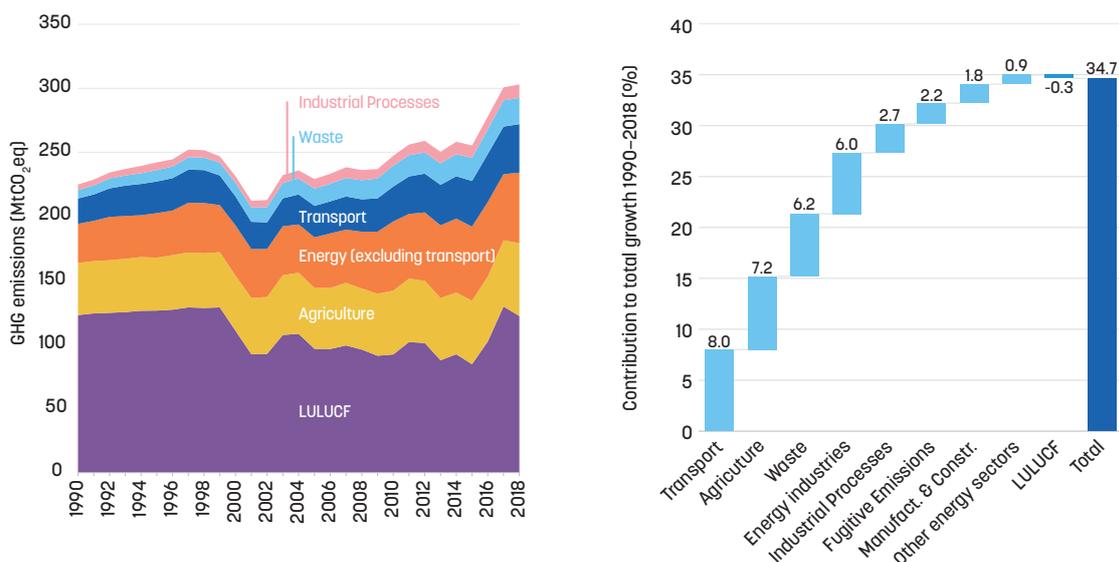
role of industry in the economy, and an increase in hydroelectric generation (Patiño, Alcántara, and Padilla 2021). Nevertheless, population growth and overall growth meant that total GHG emissions rose by 34.7 percent between 1990 and 2018, from 225 million tons of carbon dioxide equivalent (MtCO₂eq) to 303 MtCO₂eq, propelled mainly by the transport, agriculture, waste, and energy sectors (Figure 1.3). Between 2015 and 2018, the dynamic accelerated considerably, with a total emissions growth of 18.7 percent for the period, driven primarily by increased land use, land-use change, and forestry (LULUCF) emissions growth, which together represented 79 percent of total emissions growth in that period. As of 2018, LULUCF represents 40 percent of overall GHG emissions. Energy represents 31 percent (with transport—96 percent of which relies on fossil energy—representing 12.5 percent and consuming 40 percent of the country’s energy) and agriculture 19 percent (78 percent of which is from livestock).

FIGURE 1.2. Although Colombia’s GHG emissions and GDP growth have seen relative decoupling and the economy has become less carbon-intensive



Source: Government of Colombia (2022); World Bank (2022e).

FIGURE 1.3. Colombia’s GHG emissions have risen steadily, driven primarily by transport, agriculture, waste, and energy industries, and more recently, by deforestation



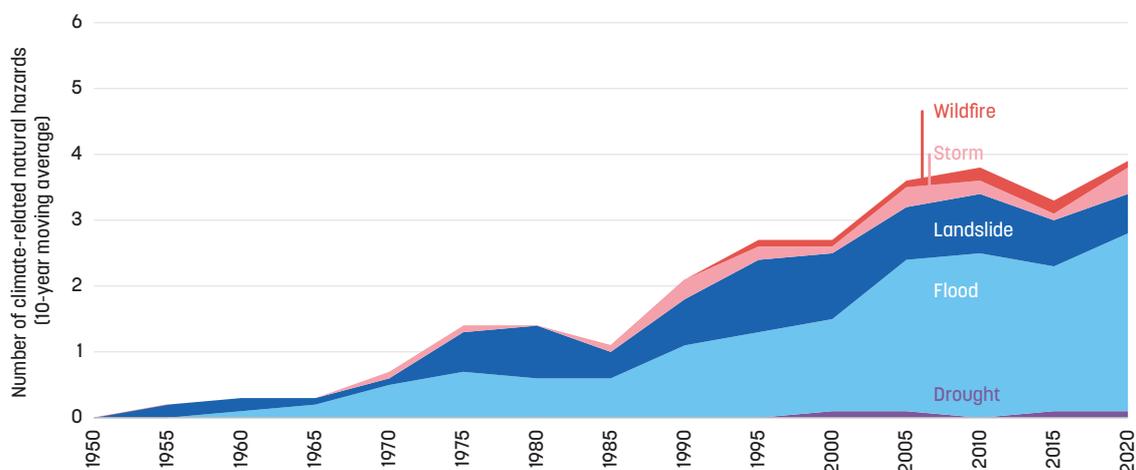
Source: Government of Colombia (2022).

The government of Colombia has ambitious development and climate action objectives. Colombia aspires to becoming a high-income country by 2040, eliminating socioeconomic gaps within its population and increasing social mobility, and promoting economic, social, and environmental development (DNP 2019; 2023). In the area of climate action, Colombia has increased the ambition of its Nationally Determined Contribution (NDC), committed to reaching net zero GHG emissions by 2050, signed the Global Methane Pledge and Glasgow Leader’s Declaration on Forests. These steps and commitments, together with a Long-Term Strategy, a climate law, and an already high share of hydroelectric power generation, present Colombia with favorable initial conditions for its climate transition (Section 2).

1.2. Climate challenges complicate Colombia’s development prospects

Climate change in Colombia is expected to bring about higher temperatures and more frequent extreme weather events, with increasing flood risks and societal and economic damage. Historical records show that the frequency of climate-related disasters has been increasing in the last decades (Figure 1.4). By 2050 the sea level of coastal Colombia could rise by between 26 (RCP 2.6) and 29 cm (RCP 8.5) (World Bank 2022b), affecting more than a million people. Moreover, the mean temperature is projected to increase from 24.97 °C in 2014 to a range between 26.02 °C (SSP2-4.5) and 26.21 °C (SSP3-7.0) in 2050, and the number of very hot days (>35 °C) is projected to increase dramatically from 13 per year in 2014 to between 66 (SSP2-4.5) and 77 (SSP3-7.0) in 2050 (World Bank 2022b). Even a 1.5 °C increase in mean temperatures in Colombia would double or triple the population affected by floods (IPCC 2022). The number of days with very heavy precipitation (>20 mm) is projected to rise slightly from 21.21 to a range between 21.44 (SSP2-4.5) and 21.67 (SSP3-7.0) over the same period. This will be accompanied by large regional variations, with rainfall increasing in Colombia’s Amazon basin and the coastal areas but decreasing in the highlands (World Bank 2021c).

FIGURE 1.4. The number of climate-related natural hazards in Colombia has been steadily increasing



Source: Guha-Sapir, Below, and Hoyois (2022).

Note: Climate-related natural hazards include climatological, hydrological, and meteorological phenomena.

These current and projected changes pose an obstacle to Colombia’s development objectives, primarily through the following channels:

- » **Damage to infrastructure.** Transport infrastructure is highly vulnerable to climate hazards, which routinely disrupt food and commodity supply chains, access to markets, and passenger connectivity. Between 1970 and 2020, combined damage to infrastructure and lost economic activity on key corridors caused an estimated US\$7.1 billion in losses. During the *La Niña* event of 2010–2011, closures and diversions of roads caused losses of approximately US\$222 million. Approximately 23 percent of all Colombian households still live in overcrowded and substandard

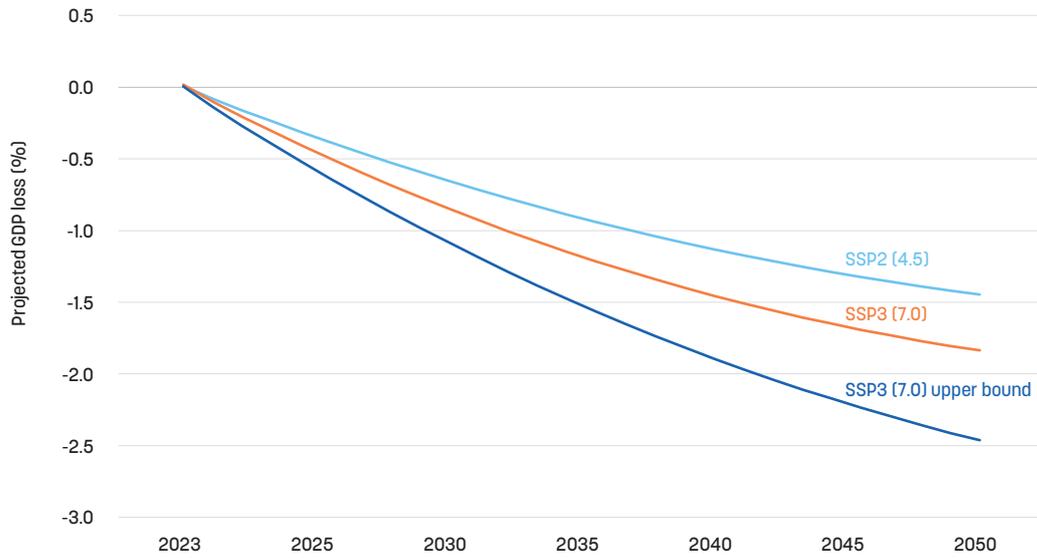
housing (DANE 2022c) that is highly vulnerable to climate impacts. The government estimates that, by 2050, flood and hurricane-induced damage to housing will represent 7.5 percent of the annual national budget allocated to housing in 2021 (Government of Colombia 2021).

- » **Disruption to electricity generation.** Hydropower generates 70 percent of Colombia's electricity, which makes electricity supply highly vulnerable to climate variability. During periods with normal hydrological conditions, hydroelectric power generation is capable of supplying about 85 percent of electricity demand. In contrast, during dry periods, such as the *El Niño* 2009–2010 and 2015–2016 periods, thermal generation sources had to cover at least 50 percent of demand, leading to high generation costs, steep rates, and heavy GHG emissions (Planas and Cárdenas 2019).
- » **Human capital losses and reduced labor productivity.** Increasing heat stress, the altered range, seasonality and distribution of vector-borne diseases (including malaria, dengue, Zika, and Chikungunya), air pollution and associated respiratory illnesses, and water-borne illnesses such as cholera and diarrhea will affect the health of Colombians and increase the clinical manifestation of cardiovascular diseases and other non-communicable diseases (World Bank 2021c). It is estimated that, in 2030, heat stress will cause lost working hours equivalent to 223,000 full-time jobs (ILO 2019) and decrease the learning abilities of children, especially where air conditioning is not available. The two main health outcomes related to temperature, cardiovascular and respiratory hospital emergency visits, are estimated to rise from around 85,000 per year in the 2010–2019 period to up to 381,000 in the 2020–2039 period, with the highest impacts in coastal cities (World Bank 2022e).
- » **Agricultural losses.** Climate shocks have already caused a 20 percent decrease in milk production and losses of up to 60 percent of total ranchers' income in some years (World Bank, 2021). Climate change is expected to further stress already low productivity in a sector that is still important for employment. By 2050, 80 percent of crops will likely be impacted in over 60 percent of their current areas of cultivation, with a particularly severe impact on high-value perennial crops (Ramirez-Villegas et al. 2012).
- » **Increasing financial risks.** Climate shocks will increase risks for the financial sector. For example, approximately 6.5 percent of banks' total loan exposure is in municipalities that face high flood risk. At the same time, the policies and technological changes necessary to green the economy will raise transition risks. These changes could strand carbon-intensive assets and affect the value of other (non-carbon related) financial assets. About 20 percent of Colombian banks' corporate loans are in sectors that are highly sensitive to transitions, including electricity generation, transport, heavy industry, agriculture, and fossil fuels. A broader set of sectors and assets are vulnerable through value-chain effects. For example, only between 2 and 4 percent of economic damage after disaster events is insured, which increases the credit risk on banks that finance borrowers exposed to disaster events (Reinders et al. 2021).

By 2050, the channels explored in this CCDR are conservatively expected to depress real annual GDP by between 1.5 and 2.5 percent. The government estimates the average annual loss due to climate risks to range between US\$1.1 billion and US\$1.2 billion (in present value terms, equivalent to about 0.3 percent of 2023 GDP), up from US\$833 million in the absence of additional climate-related damage in the future (Government of Colombia 2021). Modeling using the Mitigation, Adaptation and New Technologies Applied General Equilibrium model (MANAGE)—the World Bank's recursive, dynamic, single-country, computable, general equilibrium model—estimates that climate-induced yield losses in agriculture, increased river flooding, lower labor productivity, and losses of physical capital could cost between 1.5 and 2.5 percent of GDP by 2050 (Figure 1.5). If accumulated between 2023 and 2050, this is equivalent to losing almost one year of GDP. It is estimated that, by 2050, these losses will depress household income and reduce household consumption by between 2.1 and 3.1 percent (Figure 1.6).

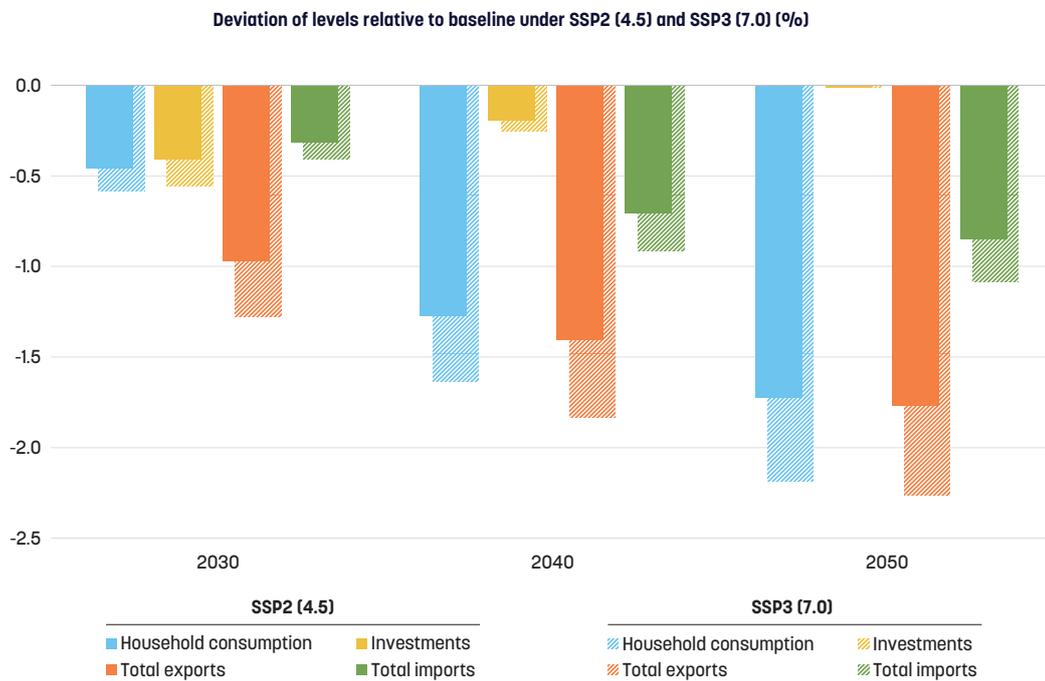
The climate shocks and economic losses described above will exacerbate inequality and poverty. By 2030, severe hydrometeorological shocks could lower the welfare of around 3 million people who are already poor and living in poorer regions (Dávalos et al. 2023). Analysis for this report estimates that, by 2050, consumption losses could amount to 2 percent for urban households and up to 3 percent for rural households (Figure 1.7).

FIGURE 1.5. Climate change would lead to GDP losses



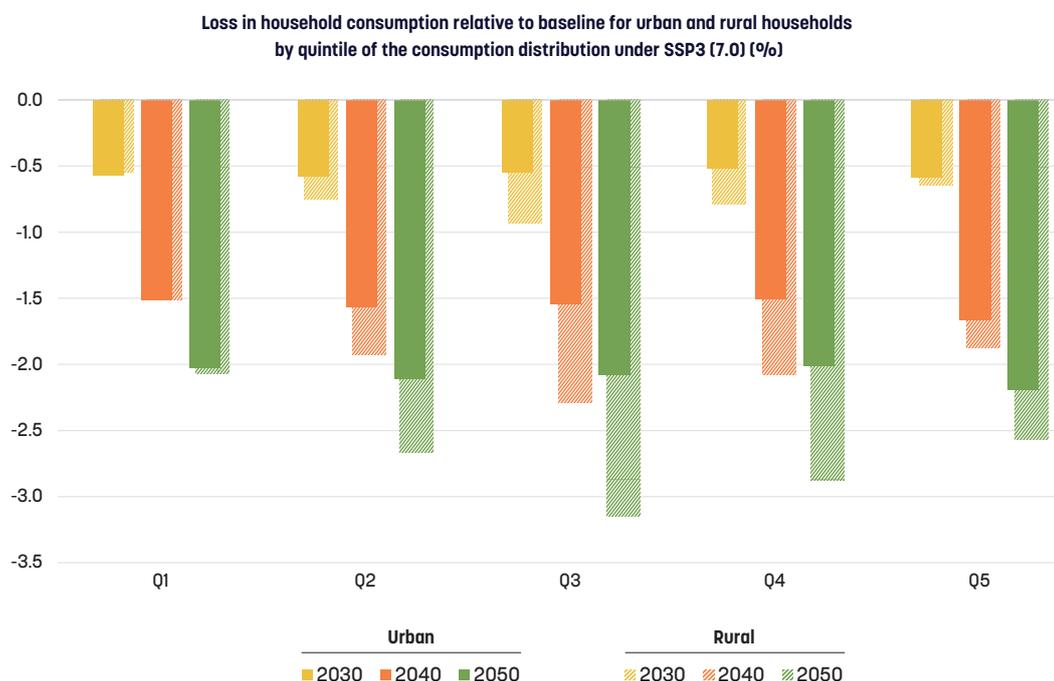
Source: World Bank staff estimates using MANAGE and based on data from DANE.

FIGURE 1.6. Climate change would reduce all components of GDP



Source: World Bank staff estimates using MANAGE and based on data from DANE.

FIGURE 1.7. Climate change would reduce household consumption more for rural households



Source: World Bank staff estimates using MANAGE and based on data from DANE.

In addition to economic risks from climate change, the decarbonization of trading partners will likely affect Colombia's trade and fiscal balance through two channels:

- » **Reduced demand for and prices of hydrocarbons, especially coal and oil.** In 2019, Colombia's hydrocarbon sector (coal, oil, and gas) generated 10 percent of the central government's fiscal revenue (ACP 2021) and 56 percent of total exports (DANE 2021b). The likely long-term decarbonization of Colombia's trading partners could reduce both Colombia's inflow of foreign currency and fiscal revenues (Section 4) and increase transition risks for the financial sector (Reinders et al. 2021), in addition to putting jobs at risk (Section 3.3.2).
- » **The enactment of climate-related trade regulations.** The Deforestation Regulation of the European Union (EU) could affect an estimated US\$1 billion of Colombia's exports (primarily coffee, palm oil, beef, and cocoa), that is, about 2.5 percent of total goods exports, requiring investments in traceability systems to maintain market share.

The transition away from hydrocarbon products will exacerbate regional inequalities and reduce local capacity to finance infrastructure. In 2019, the hydrocarbon sector provided around 107,000 jobs, mostly in the departments of Cesar, La Guajira, Bogotá, Boyacá, and Santander, with direct jobs accounting for nearly 30 percent of this total (MME 2020). In the departments of Cesar and La Guajira, the coal industry contributed 40 and 38 percent of regional GDP, respectively (DANE 2021a). Oil- and coal-producing regions receive royalties, which departments and municipalities use to finance projects such as road infrastructure, schools, and hospitals. A decrease in production will mean fewer resources for these projects. Overall, it is estimated that, by 2050, global decarbonization will cost about 8.2 percent of GDP, in addition to any direct cost from climate change.²

² In the rest of the document, it is assumed that global decarbonization results from successful emission reductions. Hence, it is assumed that global decarbonization is the result of SSP2-4.5.

1.3. Colombia's current development and growth model limits its ability to confront climate change

So far, Colombia has been growing more by accumulating factors of production (labor and capital) than by raising overall productivity, and has not leveraged innovation, investment, nor exports to lift growth and increase prosperity (World Bank forthcoming). Colombia has been able to maintain a stable macroeconomic environment favorable to growth. However, overall productivity and firms' capability are low, and infrastructure is insufficient and of poor quality.³ The economy remains relatively closed to trade, and exports are heavily concentrated in extractive industries. To be clear, Colombia is not an *oil economy*; it is an *economy with oil* (and coal). Between 2010 and 2022, the oil and mining sectors contributed only an average of about 5.4 percent of total GDP, less than agriculture (6.1 percent). However, since Colombia trades very little, oil and mining are the predominant source of foreign currency and the predominant sector that attracts foreign direct investment.

Also, structural transformation of the economy has been slow: 16 percent of the workforce remains in agriculture and two-thirds in services—mostly low-value-added sectors (DANE 2021c). Additionally, the share of employment in industry has remained stagnant since the turn of the century, reflecting the inability of the manufacturing sector to expand. There is also low competition in markets for goods and services, finance, and information. Land use is inefficient,⁴ deforestation is persistently high, agricultural productivity is low, and energy consumption depends on fossil fuels⁵ despite a relatively clean electricity generation matrix.⁶ Although the country is highly exposed to natural hazards, it lacks resilient infrastructure and has a social protection system that is not adaptive enough to quickly prevent or mitigate the exposure to climate change risks.

Colombia's development model limits its ability to confront climate change in several ways, including:

- » **Low productivity in agriculture and weak institutions for land use.** GHG mitigation will hinge on reversing deforestation, which is driven in large part by agricultural activity and underlying land grabbing (Section 3.1).
- » **The growing motorization rate and insufficient alternatives to road-based transport.** The transport sector faces the dual challenge of reducing its emissions and building climate resilience to ensure connectivity and access. The very high average age of trucks, inefficient operations, and a minimal share of rail and waterway transport drive high emissions, transport costs, and poor road safety, and the motorization rate is rapidly growing (Section 3.2.2).
- » **Limited capacity to innovate and adopt new technologies.** Mitigation and adaptation will require the adoption of new energy-efficient technologies for producing goods and services, the introduction of climate-smart agriculture, and the development of non-conventional renewable energy, among others. For example, while Colombia has been paving the way for e-mobility in Latin America, approximately 71 percent of the vehicle fleet runs on gasoline and 28 percent on diesel, with only 0.3 percent using clean technology. The public and private sectors need to work together to create the right incentives and provide access to finance for firms to innovate and adopt cleaner and more efficient production systems.
- » **Limited capacity of local governments and weak governance.** Even though subnational governments represented 51 percent of public adaptation investment in 2021, they often struggle with designing and implementing investment projects, which is reflected in their low investment execution rates of budgets linked to climate adaptation, such as DRM (Gallego Serna, Díaz Giraldo, and Ibatá Molina 2020). Increased resilience in the context of climate change will depend to a large extent on their capacity to plan, finance, and implement quality investment projects (Section 2.2).

³ The Global Competitiveness Report ranked the country's overall infrastructure 81st out of 141 countries, with the quality of road infrastructure (104th), and road connectivity (97th) being the most problematic (WEF 2020).

⁴ Land is being both drastically overexploited by the livestock sector and drastically underused in the case of agriculture and agroforestry/silvopastoral activities (UPRA 2014).

⁵ Seventy percent of the energy consumed is generated from fossil fuels (UPME 2020).

⁶ In 2019, electricity generation mainly came from hydropower (72 percent) while non-hydroelectric renewables (wind, solar, and biomass) accounted for 2.4 percent (EIA 2021).

- » **Limited fiscal space to step up public investment spending.** The climate transition requires increasing investment. The public sector will need to create fiscal space to accommodate its share of this new investment, while the private sector will need to create savings and mobilize resources to finance its share.
- » **Little use of financial markets for the financing of firms.** Colombia is at the forefront in the region in developing a supportive regulatory environment to facilitate capital mobilization for sustainable projects and enhance the financial sector's role in managing climate-related risks. The successful launch of sovereign green bonds and the development of a green taxonomy for securities issuers are important policy reforms. Yet more so than in other countries, banks (not financial markets) are the primary source of financing for firms' capital and investment (World Bank forthcoming). For the private sector to mobilize significant resources for the climate transition, enabling policies will be needed to deepen the use of financial markets for investment.
- » **Informality.** About 80 percent of productive units and 60 percent of workers in Colombia are informal (DANE 2022b; 2023). This high degree of informality makes it difficult to scale up and mainstream policies to promote resource efficiency and cleaner production (Pigato 2019). A large informal sector can also hamper efforts to raise taxes to finance public investment for adaptation.

1.4. Climate and development action offers opportunities for Colombia

Actions to increase growth and address development challenges could help Colombia reduce its exposure to climate change. Switching to a growth model that hinges more on innovation, better managerial practices, stronger institutions, and higher productivity would lift growth and support export diversification, but also reduce economic vulnerability to global decarbonization, foster the adoption of newer and greener technologies, and support a decline in deforestation. In other words, actions to upgrade the development path are complementary to actions needed for the climate transition.

Adapting to the decarbonization of trading partners offers the potential to diversify exports and improve institutions. As other countries demand relatively less oil, gas, and coal, they will also demand more "environmental" goods. As will be discussed in Section 4, although Colombia exports little of these goods, its exports of some of these goods has seen significant and dynamic growth in the past few years. If EU and US regulations on deforestation-free products are passed and implemented, complying with them will imply improving the traceability of products. This will have multiple positive spillover effects. First, it will require improving institutions related to land titling, cadaster, and forest control. It will also allow opening markets that require traceability, for example, for meat. To take advantage of these opportunities, prompt action will be critical because it is likely that the impacts from lower global demand for fossil fuels and green regulations will materialize swiftly, while structural changes can take time to occur.

Colombia has untapped potential for the sustainable use of its renewable natural resources. Land use is inefficient and unsustainable practices predominate, resulting in high environmental impact and low land productivity. Land is heavily exploited for livestock, a substantial driver of land degradation and GHG emissions, and is underused for agriculture and agroforestry/silvopasture. Reversing deforestation would have positive spillover effects on agriculture and the economy through the expansion of the ecosystem services that forests provide. The adoption of climate-smart agriculture practices to complement these efforts would also contribute to improving productivity and resilience.

Mitigation and adaptation measures are expected to have positive effects on the economy. In addition to its co-benefits of lowering the incidence of respiratory diseases and reducing road congestion and traffic-related deaths, carbon pricing can also improve firms' productivity by fostering innovation and the adoption of new technologies. The change in production and technologies required to lower emissions could also potentially create new job opportunities and require a productivity-enhancing reskilling of labor. Achieving Colombia's climate goals will require concerted and coordinated actions across the public and private sectors, with positive spillovers on private-public collaboration in areas other than the climate transition.

2. Colombia's climate commitments and their implementation

Main messages

- Colombia has set ambitious climate goals and commitments for itself, and their implementation is anchored in a comprehensive legal framework.
 - Climate is reasonably well integrated into sectoral strategy documents, and there is relative consistency of environmental policy across administrations, with a comprehensive institutional architecture that supports climate action.
 - However, there is room to strengthen coordination and institutional capacity while developing clear implementation plans for how to reach commitments. The implementation of adaptation actions could substantially improve if institutional challenges, especially at the decentralized level, were addressed.
 - Although Colombia's government has championed private sector climate action and made important strides in promoting green finance, the full potential of the private sector's contribution to climate action is yet to be harnessed.
-

2.1. Colombia has set ambitious climate goals and anchored them in a comprehensive legal and institutional framework

Colombia is a regional leader on climate change ambition. Colombia's NDC targets GHG emission reductions of 51 percent by 2030 relative to a business-as-usual scenario (Government of Colombia 2020). The target, which translates into a maximum emissions level of 169.4 MtCO₂eq and an absolute reduction of 44 percent from 2018 levels, exceeds that of regional peers. In addition, the country has furthered its commitment to protecting forests by endorsing the Glasgow Leaders' Declaration on Forest and Land Use in 2021,⁷ and has also signed on to the Global Methane Pledge, agreeing to cut global methane emissions by 30 percent by 2030 compared to 2020 levels. Colombia is also one of 8 Latin American countries to have developed a Long-Term Climate Strategy, which aims to achieve a net zero, resilient economy by 2050 (Climate Watch 2022).

Colombia's approach to climate action is anchored in a comprehensive legal climate change framework. This framework covers the adoption of international climate commitments, translates them into domestic commitments, establishes the institutional architecture for climate change management, and creates economy-wide mitigation instruments such as carbon pricing instruments. Colombia has ratified the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement and established goals and minimum measures to achieve carbon neutrality and climate resilience by enshrining the NDC targets into law. Among other major provisions, the regulatory framework creates the National Climate Change Information System, Sectoral Climate Change Management Plans (PIGCCS) for each ministry, and Territorial Climate Change Management Plans (PIGCCT) for each department.

The government has begun to translate its climate ambition into economy-wide policies to promote low-carbon, resilient development. Carbon pricing was formally adopted with the introduction of a carbon tax, and a complementary emissions trading system is planned to be piloted in 2024. In addition, the country approved guidelines for climate change management for public and private entities in order to reduce vulnerability and promote low-carbon development by defining institutional aspects and planning, monitoring, economic and financial instruments. Climate is reasonably well integrated into development policy, and there is relative stability of environmental policy across administrations.

⁷ One of 145 countries to sign the Declaration.

Development planning has consistently addressed and progressively refined climate and environmental action. The latest three National Development Plans (NDPs) have identified environmental sustainability and DRM as cornerstones of economic development, adopting a consistent approach around reducing the environmental footprint of productive activities, managing biodiversity and water, adapting to climate change, promoting low-carbon development, and improving institutions and governance. Significant improvements over time include the introduction of deforestation control and emission reduction goals, the introduction and expansion of economic instruments such as payments for ecosystem services, and the mandate to implement adaptation measures at the department level. Moreover, the 2022–2026 NDP includes productive transformation and climate action as development cornerstones.

Medium-term public policy instruments define climate action priorities, while national strategies and plans facilitate their implementation. Examples of such instruments include the National Climate Change Policy to incorporate climate change management into public and private decisions, the National Policy for Disaster Risk Management, and the Green Growth Policy, whose objective is to boost the country's productivity and competitiveness while ensuring the sustainable use of natural capital and social inclusion. Similarly, the Colombian Low Carbon Development Strategy seeks to decouple GHG emissions from economic growth, the National Circular Economy Strategy seeks to make the economy more resource-efficient, and the National Adaptation Plan aims to reduce vulnerability and increase response capacity to climate change impacts.

The country has also prioritized sectoral climate action, for example, by promoting non-conventional, renewable energy. Other examples include developing a strategy for reducing emissions from deforestation and forest degradation (REDD+)—which is a policy for the control of deforestation and sustainable forest management—a policy for sustainable buildings; and policies for developing sustainable transport infrastructure projects, promoting electric mobility, and regulating the reuse of wastewater.

Colombia' institutional climate change architecture is organized around SISCLIMA. SISCLIMA coordinates, formulates, monitors, and evaluates policies, strategies, projects, and measures for climate change adaptation and mitigation through collaborations among public, private, and nonprofit organizations. SISCLIMA is guided by the minister-level Intersectoral Commission on Climate Change (CICC), which oversees climate efforts in coordination with the Regional Nodes for Climate Change (*Nodos Regionales de Cambio Climático*) and local administrations and environmental authorities. In addition, the Intersectoral Commission of the Presidential Cabinet for Climate Action coordinates and evaluates the executive branch's progress in achieving the government's international climate commitments. The authority charged with overall climate policy and the implementation of Colombia's NDC is the Ministry of Environment and Sustainable Development (*Ministerio de Ambiente y Desarrollo Sostenible*, MADS), while the National Unit for Disaster Risk Management (*Unidad Nacional de Gestión de Riesgos de Desastres*, UNGRD) directs the implementation of disaster risk management.

2.2. Implementation of adaptation faces challenges, especially at the decentralized level

Overall investments in adaptation remain low and do not systematically target departments with the highest exposure to climate-related hazards. Between 2011 and 2021, Colombia's budget for climate action reached US\$9.9 billion, 43 percent of which was invested in adaptation, 22 percent in mitigation, and 35 percent in adaptation and mitigation simultaneously (DNP 2022). However, funding does not systematically target departments with the largest hazard exposure, and all departments have a low alignment between risk levels and adaptation investments.⁸ In addition, nearly 90 percent of municipalities spend less than 1 percent of their total investment budget on adaptation, and only 22 of

⁸ The Investment Indicator based on departmental risk calculated by DNP, shows a substantial misalignment between investment and risk level for all departments with a performance ranging from 16.7 to 68.7, where a score of a 100 represents the optimal level.

Colombia's 1103 municipalities spend more than 5 percent.⁹ Moreover, subnational governments rely largely on their own revenue to finance disaster risk management investment, implying that subnational governments with less own revenue likely have fewer resources to invest in disaster risk management.

Decentralized implementation of adaptation faces substantial hurdles. Subnational governments accounted for 51 percent of public adaptation investment execution in 2021. Municipalities allocate an average of 1.8 percent of their total budget to DRM, more than the 1.2 percent and 0.7 percent by national and regional governments, respectively. Given the widespread exposure to climate-induced disasters in Colombia, this functions as a useful proxy for climate adaptation. However, subnational governments often struggle with designing and implementing investment projects, which is reflected in their low investment execution rates: From 2011 to 2019, municipal governments committed only 74 percent and executed 46 percent of their budget allocated to DRM investment (Gallego Serna, Díaz Giraldo, and Ibatá Molina 2020). Based on limited sampling conducted for this report (World Bank 2022f), the performance of the Regional Climate Change Nodes, which are supposed to help translate climate objectives from the central to the territorial level, is hindered by a lack of human and financial resources, and in many cases, a lack of buy-in from departmental and municipal governments. Although the law requires that departments and municipalities incorporate climate actions set out in the integrated territorial climate change management plans (*Plan Integral de Gestión del Cambio Climático Territorial*, PIGCCT) into their development plans, in practice, only an average of 30 percent of these actions are thus incorporated, and only 34 percent are incorporated in the investment projects of the sampled departments. Interviews with subnational government officials point to several obstacles:

- » The absence of procedures and mechanisms for translating PIGCCT actions into development plans and investment projects.
- » Limited coordination between departments and municipalities.
- » A low level of awareness of municipal officials, which means that many infrastructure projects and investments lack adaptation and resilience considerations.
- » Insufficient capacity at the municipal level to plan and design investment projects for adaptation. Specifically, central government support focuses more on mitigation and DRM, and the risk and vulnerability assessments that are provided lack the fine level of granularity needed to inform municipal decision making; the majority of municipal governments do not have the capacity to conduct their own assessment.
- » Financing constraints in small municipalities with limited own revenue.

To help overcome these hurdles, the central government could develop instruments to help subnational government plan and invest in adaptation. First, it could conduct and regularly update risk and vulnerability assessments with the level of granularity needed to inform subnational government planning. It could also develop guidelines and methodologies to aid subnational adaptation planning, such as a handbook with a catalog of different types of adaptation actions. Finally, the central government could develop template projects (*proyectos tipo*) for climate adaptation and, if relevant, update the current template projects to include adaptation and resilience considerations.

2.3. In spite of a strong framework, coordination, consistency and implementation challenges remain

Although the legal and institutional framework provides a solid foundation for the development and implementation of climate policy, there is room to further improve the effectiveness of climate action. The legal framework builds a solid theoretical institutional architecture by focusing on the

⁹Based on data from the *Sistema MRV de Financiamiento Climático* and *Sistema de Información del Formulario Único Territorial*.

creation of institutional arrangements and on the development of planning instruments and information systems, but it does not functionally address vital issues that hinder the coordination of agencies and policies, including limited resources and understaffing, fragmented governance, limited institutional capacity at decentralized government levels, and limited information availability to design policies. Hence, the current institutional and legal framework needs to be complemented by measures to increase its effectiveness, including:

- » Improving coordination between national agencies to ensure climate policy alignment.
- » Strengthening coordination between the central and decentralized levels of government, for example, through the climate change nodes.
- » Strengthening the ability of SISCLIMA's committees to inform decisions of the CICC.
- » Providing technical assistance to ensure consistently high quality across territorial planning and adaptation instruments, with a focus on the most vulnerable territories.
- » Mainstreaming adaptation at different levels of territorial planning.
- » Bolstering coordination between SISCLIMA and the National System for Disaster Risk Management.
- » Monitoring the results of NDC and LTS achievement and publicizing them—possibly through an independent body.

Similarly, while Colombia's updated NDC is one of the most ambitious in the region, so far it lacks a comprehensive strategy to support its mitigation target. Mitigation measures in the NDC at best add up to emission reductions of 37 percent GHG compared to the 51 percent reduction goal (World Bank 2022h). This highlights the urgent need to agree on and implement additional mitigation measures, while moving forward with the rapid implementation of existing priority steps. Colombia's climate policies and commitments are not yet consistent with the Paris Agreement's 1.5 °C target. Though the country will not meet its NDC target with current policies and actions, its planned policies may just allow it to do so (CAT 2022). Colombia will need to implement additional policies but will also need international support to implement further policies in line with full decarbonization.

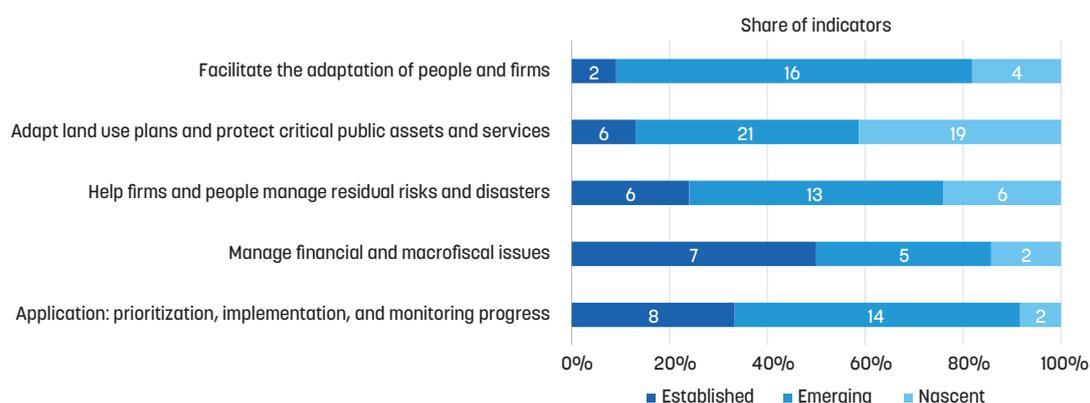
Moreover, there is room to improve policy consistency by overcoming certain remaining contradictions. Climate targets across planning instruments are not always consistent. This is exemplified in the mismatch between the NDC mitigation goal—highly dependent on the Agriculture Forestry and Other Land Use (AFOLU) sector (65.2 percent of mitigation burden)—and the 2022–2026 National Development Plan (NDP) deforestation goal for 2026, which puts forth a deforestation target 39 percent higher than the NDC's 2025 milestone (Figure 3.1). It is also exemplified by the inconsistency in the electrification of the energy matrix target for 2050 stated in the National Energy Plan (between 18 and 26 percent) and the LTS (between 40 and 70 percent). In addition, efforts to make progress on carbon pricing are blunted by the implicit subsidy to fossil fuels embedded in the price-smoothing mechanism for gasoline and diesel (Section 4). Similarly, the unplanned construction of rural roads in environmentally sensitive areas, frequently by decentralized government levels, fuels deforestation by opening up previously isolated areas and contributing to land speculation. For example, in the Amazon, 42 percent of deforestation occurred within one kilometer of a road (World Bank 2023f). Finally, land titling in forest reserves—where it is in theory illegal—has contributed to land-use change (González Arenas et al. 2018).

On the adaptation side, Colombia has advanced significantly in generating a solid institutional and political framework for disaster risk management and climate change adaptation, but gaps remain in infrastructure, agriculture, and disaster recovery. Significant progress has been made in the three processes of DRM—risk knowledge, risk reduction, and preparedness, response, and recovery. However, several challenges remain. These are related mainly to policy implementation and instruments, advancing risk knowledge in sectors and at local scales, implementing resilient infrastructure, and generating the required capacities at local level. To assess progress and identify priorities for adaptation, this report uses

a conceptual framework developed by Hallegatte, Rentschler, and Rozenberg (2020). The framework is organized into 27 actions centered around five pillars that reflect universal principles for effective climate change adaptation, and with 153 indicators that measure projects along three maturity levels (Figure 2.1). The analysis finds that the largest gaps—defined as actions with a larger share of nascent and emerging indicators—are as follows:

- » **Promoting a comprehensive government approach to adaptation is vital to increasing public infrastructure resilience.** Essential components of a government-wide strategy to strengthen public infrastructure resilience—such as an updated resilient infrastructure plan, a dedicated resilience unit for the transport sector, and a modern asset management system of the primary road network to track asset maintenance and repair history—are still lacking or need substantial improvement.
- » **Building back better after disasters requires principles and guidelines for reconstruction.** The 2018–2022 National Development Plan (NDP) establishes that the UNGRD and the National Planning Department will prepare a strategy of disaster-resilient recovery adapted to climate change, and will define the coordination instruments, roles, and responsibilities in DRM, as well as recovery and resource management mechanisms according to the magnitude and impact of the disaster. To date, however, this strategy is not in place. Furthermore, reconstruction experiences in the last decades have shown that these generally take more than five years. Principles, guidelines, and procedures to build back better in an efficient manner may therefore provide the means for a more rapid reconstruction.
- » **Increasing the resilience of the agriculture sector is especially important for rural populations and food security.** This requires the transformation of the agriculture innovation system, better access to financial instruments such as credit and insurance, the implementation of early warning systems, and the improvement of risk knowledge in the agricultural sector. Although agricultural insurance schemes are being implemented, their current penetration and geographical coverage are still limited, and some of the schemes have not yet been scaled up beyond pilot stage.

FIGURE 2.1. The state of adaptation and resilience in Colombia



Source: World Bank (2022a).

Note: Numbers on each bar show the number of indicators per category (established/emerging/nascent). The underlying analysis uses a combination of quantitative data, review of government, World Bank and other publicly available documents and input from World Bank staff.

2.4. Colombia is a leader in creating the conditions for private climate finance

The private sector was actively engaged in Colombia’s NDC update process, but efforts to deepen private involvement need to continue. A number of prioritized stakeholders were selected based on their potential to implement mitigation actions or be affected by them. As a result, the mitigation portfolio includes 24 measures led by 7 private businesses—from the hydrocarbons, food and beverages, energy, transport, mining, retail, and automotive sectors. In addition, in 2020, the government led the

development of a strategy to strengthen the private sector's climate risk management capabilities in the water, agriculture, urban development, and financial sectors. Despite these efforts, nevertheless, private sector involvement in climate financing remains limited: between 2011 and 2021, private resources made up only 9.7 percent of total investments in mitigation and adaptation, with just over half going to mitigation (World Bank 2022d).

Authorities are making significant efforts to develop green finance by promoting financial intermediaries' adoption of green standards and working with the financial sector to channel financing into bankable green investment projects. In 2022, Colombia became the first Western Hemisphere country to adopt a national green taxonomy. The taxonomy, which identifies and classifies green assets and economic activities and aligns them with climate mitigation and adaptation objectives, is to be used by all financial market participants, including issuers, investors, financial institutions, and public sector entities. Moreover, the Financial Superintendence of Colombia has been incorporating climate-related elements (including disclosure and transparency requirements) in financial sector regulations, developing tools for measuring and supervising climate-related risks, regulating green financial instruments, and providing training. The Financial Superintendence's 2022 Roadmap for Greening the Financial Sector maps the way forward.

The financial sector is developing the green finance market. As of 2022, 7 out of 30 banking institutions in Colombia had carbon-neutrality goals for 2050. In addition, 25 financial institutions have adhered to the 2022–2027 renewal of the Green Protocol,¹⁰ and 12 of them are including Environmental and Social Risk Analysis Systems in their financing-approval processes (Asobancaria 2021). Although the largest banks in Colombia still have a strong presence in emissive sectors,¹¹ green credits more than doubled between 2020 and 2022 (from 2.4 to 5.0 percent). Additionally, 5 commercial banks are offering green mortgages and/or some type of financing for green construction, 18 financial institutions have stated their plans to measure financed emissions by 2025, and 6 are at various stages of doing so. As an extension of the green taxonomy, the development of a blue taxonomy has become a priority. It will allow the private sector to play a leading role in raising funds for water-related projects, such as safeguarding access to clean water, wastewater treatment plants, plastic recycling, marine ecosystem restoration, sustainable shipping, ecotourism, and offshore renewable energy.

The public sector, through regulators and second-tier financial institutions, is also playing a role in shaping climate investment. As a member of the Sustainable Banking and Finance Network—a platform for knowledge sharing and capacity building on sustainable finance for financial sector regulators and industry associations across emerging markets—the Finance Superintendence of Colombia co-chairs the measurement working group and has contributed to creating a systematic approach to assessing country progress in the development of national sustainable finance frameworks. Public development banks FINAGRO, Bancoldex and FINETER are signatories to the Green Protocol. The latter two have incorporated support for mitigation and adaptation initiatives through the introduction of credit lines and support programs for transport and energy efficiency.

Nonetheless, despite much progress to date, the green financial sector could be developed further. For example, public development banks have not yet taken ownership of the national green taxonomy and could expand their offers of blended finance products beyond transport and energy efficiency. Additionally, lending in the agricultural sector could better incorporate climate criteria—for example, criteria aimed at creating incentives for financial institutions to provide preferential credit lines to support the adoption of climate-smart agriculture practices.

¹⁰ The Green Protocol is a voluntary agreement founded on five strategic pillars: development of green products and services, ecoefficiency, adoption of Environmental and Social Risk Analysis Systems (SARAS), disclosure and transparency, and integration of climate change in management.

¹¹ From 2019 to 2020, the three largest banks in Colombia committed more than US\$19.3 billion toward the three primary emitting sectors (agriculture, transport, and electricity). Source: IFC analysis of financial statements from Bancolombia, Davivienda and Banco de Bogotá.

From a resilience perspective, losses to the financial sector due to physical and transition risks associated with climate change could have significant impacts.

The sector remains vulnerable to large-scale losses from one or a combination of severe weather events. In addition, transition risks posed by the policy and technological changes necessary to achieve a greener economy could strand carbon-intensive assets and affect the value of other financial instruments. Colombia was the first Latin American country to carry out a climate stress test of its financial sector. About 20 percent of Colombian banks' corporate loans are in sectors that are highly sensitive to transitions, whereas a broader set of sectors and assets is vulnerable through value-chain effects. Other risks include those posed by the high share of fossil fuel in Colombia's export revenues, the high carbon intensity of manufacturing exports compared to other countries in the region, changes in domestic climate policies, climate regulation abroad, technological change, and shifting consumer preferences. The insurance sector could also suffer from an increase of claims related to climate-induced natural disasters, which could compromise the sector's economic sustainability (Reinders et al. 2021).

3. Pathways to resilience and decarbonization

Main messages

- Colombia could theoretically achieve its 2050 net-zero emissions target, and the investments required in the process would generate many wider benefits and a positive net economic impact. However, meeting that goal will require swift and transformative action.
- Controlling deforestation will require a strong commitment to regulating and enforcing measures against land grabbing, and to improving governance, complemented by building a climate-smart agriculture sector and a sustainable forest economy to increase productivity, resilience, and mitigation.
- To close current infrastructure gaps across the country, investments in the climate adaptation of the transport, energy and water infrastructure sectors will be needed.
- Decarbonization of transport, power and industry will require economy-wide electrification, efficiency measures, investment in new electricity generation, and determined commitment to transforming the transport sector.
- Because climate impacts will increase poverty and deepen inequalities, improvements in social protection programs will be especially relevant for coping with climate shocks.
- The Resilient and Net Zero Pathway for Colombia is likely to result in net job creation, but a well-thought out policy initiative, including training and reskilling programs, compensatory transfers, or incentives for technology adoption, may facilitate the just transition of at-risk jobs.

3.1. Sustainable, productive landscapes for climate adaptation and mitigation

Main messages

- * Without substantially departing from historical deforestation and land use trends, Colombia will not meet its low-carbon development objectives.
- * Achieving this goal will require, as a matter of priority, more effective deforestation control and governance, bringing land grabbing under control, and productivity improvements in agricultural production inside the agricultural frontier.
- * However, Colombia stands to benefit substantially from achieving its targets: While investments of US\$36 billion would be required over 2022–2050, economic and social benefits of US\$65 billion would result. A large part of these benefits would result from ecosystem services that will boost Colombia's resilience amid climate change.

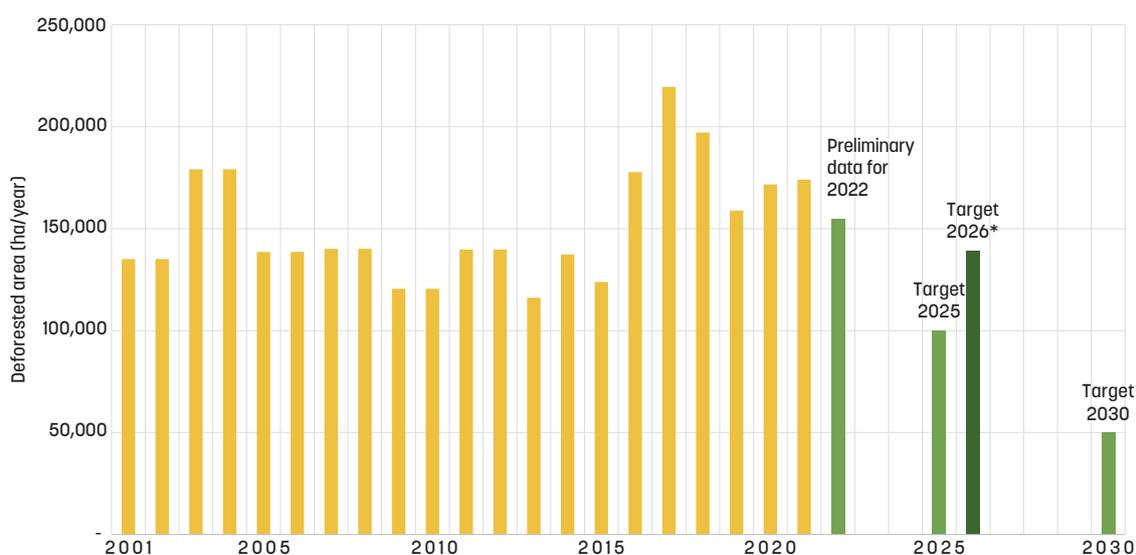
Colombia by and large has not used its immense wealth in land and forest resources sustainably, having lost nearly 3.2 million ha of forests between 2001 and 2021 (IDEAM 2022). Consistently high rates of deforestation have been intertwined with low agricultural productivity. Given the crucial linkages between land use, Colombia's peace agenda, and rural employment, resolving the land-use conundrum is not only the main key to fulfilling Colombia's climate ambitions from both adaptation and mitigation perspectives, but also important for Colombia's development writ large.

3.1.1. Controlling deforestation is the key to Colombia's mitigation and adaptation puzzle

Land-use change represents Colombia's largest source of GHG emissions. Forests cover 52 percent (59.7 million ha) of Colombia's land territory (IDEAM 2020). However, between 2001 and 2021, the country lost nearly 3.2 million ha of those forests (IDEAM 2022), at least 89 percent of it through illegal practices (Dummett et al. 2021). Over this period, the rate of deforestation has remained stubbornly high on average. However, a marked acceleration took place upon the signing of the peace agreement in 2016 (Figure 3.1). As a result, by 2018 LULUCF represented 40 percent of Colombia's total GHG emissions, while sequestration by forests and land offset represented around 7.6 percent of total GHG emissions (Government of Colombia 2022).

Deforestation carries significant economic and social costs for Colombia and affects its ability to adapt to climate change. Approximately 24 percent of Colombian ecosystems are critically endangered or at risk of collapse, in large part due to deforestation (Etter et al. 2017). Johnson et al. (2021) estimate that, by 2030, a partial collapse of healthy ecosystems could reduce GDP growth by 13 percent. This would primarily affect the poorest and most vulnerable segments of the population, who are most dependent on natural resources. Deforestation also threatens globally important biodiversity and results in a loss of ecosystem services relevant to adaptation, such as temperature regulation, water retention and purification, soil conservation, and food provision. At the same time, the government has estimated a potential of US\$7.4 billion in exports from the bioeconomy (DNP 2018), a potential that deforestation is threatening to reduce. The same applies to the country's tourism potential.

FIGURE 3.1. Deforestation rates have been persistently high for 20 years, with a marked rise since 2015; achieving deforestation targets will require a dramatic reversal



Source: Government of Colombia (2020, 2023); IDEAM (2020).

Note: 2022, 2025 and 2030 targets are from the NDC. The target for 2026* is from the 2022–2026 NDP.

Without drastically reducing land-use change, Colombia's 2030 and 2050 climate commitments will remain out of reach. Colombia's net-zero pathway for 2050 suggests that 52 percent of emission reductions needed by 2030 would need to come from reduced land-use change (Section 3.4). Recognizing the important role forests and land play in the country's adaptation and mitigation strategy, Colombia's NDC commits to limiting deforestation to 50,000 ha/year by 2030.¹² However, mitigation pathway modeling suggests that given the challenges to implementation in other sectors, Colombia would need to reduce deforestation to no more than 37,500 ha/year to reach its NDC target (VITO and Uniandes forthcoming). This would be a level

¹²Although Colombia has significant sequestration and reforestation potential, the NDC includes no specific targets for these. In addition, by signing the Glasgow Leaders' Declaration on Forests and Land Use, Colombia committed to halting and reversing forest loss and land degradation by 2030, a commitment that goes further than the NDC. It remains to be seen how Colombia will translate this into policy.

Colombia has not seen since the beginning of deforestation data collection in 2001, illustrating the scale of the challenge (Figure 3.1). In addition, by 2030, 25,000 ha would need to be reforested, 620,000 ha afforested, and 5.8 million ha of land restored.¹³

Achieving transformational deforestation control will require addressing the drivers of deforestation, the most important direct ones being livestock and agricultural expansion. The primary direct drivers of deforestation are expansion of the agricultural and livestock frontier, and to a lesser extent, illicit drug cultivation, mining, and illegal logging. The relative importance of these drivers varies by region, but at the national level, livestock and agriculture stand out as by far the most important direct drivers (González Arenas et al. 2018; Murillo-Sandoval et al. 2023).¹⁴

However, the conversion of land to grazing and agricultural uses obscures the fact that land grabbing for speculative purposes is a major underlying driver of land-use change (Dávalos et al. 2014; World Bank 2023f). Land grabbing is the primary factor behind deforestation in the Colombian Amazon, and accounted for 61 percent of the country's total deforestation in 2021 (IDEAM 2022).¹⁵ It involves both state and non-state, legal as well as illegal, and formal as well as informal actors (Borras et al. 2013). It is financed and orchestrated by hidden or dubious business owners (UNODC 2022) who collaborate with suppliers, interim landowners, and the state, and who facilitate the clearing and occupying of land and its trade (Insight Crime and Instituto Igarapé 2022; WWF 2021). The Northwestern Arc of the Amazon lost about 89,000 ha of forest in 2020 and 2021.

For deforestation to occur, land must be legally occupied or illegally appropriated. In the Colombian Amazon, deforestation occurs overwhelmingly on public land (*baldíos*), in collective territories of ethnic communities, or in protected areas, and no such land can enter the legal land market. Illegally appropriated land is mainly transformed into pasture: The cattle census predicts 90 percent of the variability in deforestation, and 4 million new head of cattle were recorded in the area between 2016 and 2020 (World Bank 2023f). The expansion of road networks plays an important role in determining where land grabbing—and therefore deforestation—occurs. For example, 69 percent of land deforested between 2020 and 2021 is less than 2 km away from roads; and just in the 12 months from March 2021 to March 2022, 742 km of new roads were constructed in the Colombian Amazon (FCDS 2022).

Although the implementation of the peace agenda represents a historic opportunity, it also poses significant challenges for containing deforestation. After the government's peace agreement with the Revolutionary Armed Forces of Colombia (FARC), there was a large increase in deforestation in areas previously controlled by the FARC as the state was unable to fill the power vacuum resulting from the FARC's demobilization: Other insurgents and criminal groups have stepped up economic activities—ranching, logging, mining and coca growing—that accelerate the loss of forest in areas that the guerrilla once controlled (International Crisis Group 2021). The deforestation effect of peace was exacerbated by land-intensive economic activities but attenuated in municipalities with higher state presence and judicial capacity (Prem, Saavedra, and Vargas 2020). The challenges to implementing the peace agreement, such as integrated rural reform to address unequal and informal landholding, improving the competitiveness of the rural economy, and establishing a comprehensive state presence in remote areas, could simultaneously advance the deforestation control agenda.

Colombia has significant potential to reduce emissions using nature-based solutions and could reach its deforestation target without compromising development by simultaneously investing in deforestation control and sustainable agricultural productivity. The cost-effective technical emission reductions potential in the land-use and agriculture sector is about 219 MtCO₂e/year (Roe et al. 2021). In addition, key measures in the NDC's AFOLU mitigation portfolio such as deforestation control, ecological restoration,

¹³ This CCDR focuses on deforestation control as the subsector with the highest short-term mitigation potential, in addition to high irreversibility and large co-benefits.

¹⁴ Between 2005 and 2012, 90 percent of forest loss stemmed from conversion into pastures (50 percent), bushland (28 percent), cropland (7 percent), and grasslands (5 percent) (González Arenas et al. 2018). Data from 2021 suggest that this trend has held over time (WRI 2022).

¹⁵ Although deforestation is also a critical challenge in other parts of Colombia, deforestation dynamics differ across the country, exceeding the scope of the analysis conducted for this CCDR. The CCDR therefore concentrates on the Colombian Amazon as the region that most contributes to national deforestation.

and commercial forestry have a very low marginal abatement cost, in some cases below US\$2/tCO₂eq (VITO and Uniandes). Building on Banerjee et al. (2021), this report calculates that, when taking into account the natural capital assets and environmental quality that underpin economic growth,¹⁶ achieving a zero deforestation rate by 2035 would increase GDP by US\$456 million in 2035 compared to a continuation of the baseline 2016–2018 deforestation rate.¹⁷ In other words, one hectare of avoided deforestation would increase Colombia's GDP by US\$90 at constant prices.¹⁸ Historically, growth in Colombia's agriculture sector has relied disproportionately on increasing the area under production, to the detriment of its forests. A combination of policies leading to avoided deforestation, increased agricultural productivity (Section 3.1.2), and investments of resulting tax revenue in expanded public services could decrease poverty by 0.15 percentage points (Banerjee et al. 2021).

To achieve transformational deforestation control goals, Colombia could consider evaluating its institutional and governance arrangements to reinforce a well-coordinated approach that spans the breadth of the government agenda. Colombia's decentralized environmental management system means that implementation of deforestation control on the ground is currently relatively disconnected from central government policy making, such that national climate goals are difficult to translate into action. Departments have substantial leeway in making investment decisions, and their agendas do not necessarily align with limiting land-use change. Their agendas are also subject to capture, as elected officials frequently have vested economic interests. The Ministry of Environment and Sustainable Development has very limited reach on the ground, and, together with its specialized agencies, is chronically underfunded, meaning that crucial functions, such as real-time forest monitoring, rely on unpredictable donor funds. Meanwhile, the decentralized Regional Autonomous Corporations (*Corporaciones Autónomas Regionales*, CARs), charged with environmental management, have highly varying capacity, limited enforcement means, and limited oversight. Environmental law enforcement recently suffered from an authoritarian approach that targeted small actors rather than financiers of deforestation, although the government is seeking to change this approach. Given the scale and the cross-sectoral nature of the deforestation control challenge, and the need to involve actors across layers of government, Colombia could evaluate the benefits of streamlining its institutional set-up, coordinating the response at the highest levels of government and allocating more decision-making power to the central government.

Scaled action is required in five principal areas:

- » **Law enforcement will need to become more effective:** This includes strengthening the ability of the law enforcement and judicial apparatus to target strategic actors responsible for large-scale deforestation, including by strengthening investigative capacity, harmonizing agrarian and judicial procedures for expropriation in deforested areas, defining criteria for valuing the damage resulting from deforestation, and creating restitution mechanisms.
- » **Land grabbing must be brought in check, with a focus on the areas of highest deforestation:** Achieving this would involve expanding the coverage of the multipurpose cadaster and updating its information, and connecting the public lands inventory with land registry information; updating registration folios and integrating registration, notary, and cadastral information; creating registry codes and mandatory identification of properties located in reserve areas, protected areas, and reservations; controlling the establishment of new sub-municipal areas (*veredas*) and investigating the creation of new *veredas* in highly deforested areas; strengthening the legal framework for crimes linked to deforestation and land grabbing; outlawing most economic activity in *baldío* lands to disincentivize land grabbing while accounting for and formalizing existing property rights; strengthening judicial analysis and pursuit of land grabbing, with a focus on the financiers; seizing illegally deforested land; creating a livestock traceability system to ensure the legal origin of livestock and linking it to land administration data, which would also help preserve and develop export markets in the EU, in light of its deforestation-free regulation; phasing

¹⁶ As represented by the Genuine Savings indicator of wealth (World Bank 1997).

¹⁷ Based on the results of Banerjee et al. (2021) using the marginal relation between deforestation and GDP. Using the results, the impacts on GDP and the genuine savings were updated using updated historical deforestation rates and the NDC's deforestation target of 50,000 ha/year by 2030.

¹⁸ The marginal cost is estimated as the change in GDP over the change in deforestation in Banerjee et al.'s (2021) DEFOR scenario in 2020 and 2030. This value is real change over time.

out implicit incentives by public development banks and decentralized governments for cattle ranching outside of the agricultural frontier, thereby eliminating incentives for purchasing cattle, species improvement, and the creation of farm infrastructure; and creating employment alternatives for unskilled and low-skilled labor otherwise available for land clearing, in particular in urban areas.

- » **Sustainable production and restoration in deforestation hotspots along the agricultural frontier and in environmentally strategic areas will need to be scaled up and give value to standing forests.** Supporting the economic and social development of rural communities, and closing the agricultural frontier, would benefit from scaled-up incentive programs such as payments for environmental services, production-conservation agreements, and natural resource management models such as community forestry and nature-based tourism. For these to flourish, the enabling environment would benefit from accelerated implementation of the multipurpose cadaster and land property regularization, the resolution of land-use conflicts based on inclusive land-use planning, the conclusion of conservation agreements with communities, the issuance of land-use contracts, the provision of technical assistance, support for market, industry and trade linkages for targeted value chains, and collaboration with the private sector (for example, by building on existing Zero-Deforestation Agreements between the government and buyers).
- » **The enabling policy environment needs to be strengthened.** This will involve aligning policies horizontally (between central line ministries) and vertically (between national, departmental, and municipal governments), for example, aligning agricultural support with environmental goals (incentives and credit, research and development, extension, traceability systems), land taxes (for which a minimum tax could be introduced to disincentivize extensive agriculture, or transport planning and financing for consistency with deforestation control objectives. Examples of vertical alignment include the creation of incentives for subnational governments to manage forests sustainably, conditioning access to credit from national development banks (NDBs) to incentivize decentralized performance in managing deforestation, conditioning fiscal transfers to decentralized governments on deforestation performance, and rewarding performance in implementing policies (for example, completing the cadaster and application of green infrastructure guidelines). Overall implementation would be easier if natural resource management were less fragmented.
- » **Institutional and community governance will need strengthening:** This includes strengthening the land rights of indigenous peoples and local communities, who are proven natural resource stewards, and strengthening the role of the Indigenous Environmental Authorities;¹⁹ reducing the fragmentation of natural resource management between the central and decentralized governments and enhancing the effectiveness of the CARs in environmental management, including by promoting transparency, accountability, and efficiency; bolstering the National Natural Parks Unit; and making forest-monitoring data accessible at the frequency and resolution required for them to be used as an effective decision-making tool, from the central government down to the community level.

More broadly, stopping deforestation and supporting sustainable development requires a comprehensive and diverse set of policies, including in the macroeconomic area. There are important interdependencies between rural and urban productivity (Hertel 2012; Cheston et al. 2023): Increased urban productivity can take the economic pressure off the agricultural frontier by attracting capital and labor to activities other than agriculture, and by supporting an appreciation of the real effective exchange rate through higher wages in the manufacturing sector. Increased productivity in manufacturing and economic development of urban areas complements policies directed a forest control and protection and strengthen the effect of these policies on deforestation. In adjusting its deforestation control strategy, Colombia should therefore not neglect promoting urban development, especially near areas of high deforestation.

An ambitious deforestation control agenda requires a strong financing strategy. As a starting point, bottlenecks to the efficient use of public resources in the environment sector need to be resolved—budget execution in more than half the entities that make up the Sistema Nacional Ambiental is below 36 percent,

¹⁹ Indigenous Peoples and Local Communities (IPLCs) hold 38.2 percent of Colombia's land. Nationally, the rate of carbon loss on IPLC land is less than half of that on other lands in Colombia (WRI and Climate Focus 2022).

and in 11 CARs the level is below 20 percent (MADS and DNP 2022)—in order to improve impact and reduce dependence on external funding in strategic areas such as forest monitoring. A broader financing strategy should consider innovative new financing sources to mobilize public and private capital (for example, fiscal sources, grant/concessional financing, green and performance-linked bonds, debt-for-nature swaps) and market mechanisms (for example, carbon markets, jurisdictional REDD+ programs) that combine domestic and international sources and efficiently coordinate international assistance for scale.

As part of this, Colombia could tap into underutilized carbon finance. Building on analysis by Streck et al. (2022), Colombia has an estimated technical potential to mobilize an average of US\$1.1 billion per year in carbon finance between 2021 and 2035 from avoided deforestation, afforestation/reforestation, and improved forest management alone.²⁰ This compares to an estimated total cost of implementing Colombia's national REDD+ strategy of US\$2.9 billion (in 2023 dollars) between 2018 and 2030 (Government of Colombia 2018). Although international carbon markets are still at an early stage of development, Colombia could position itself by preparing itself for scaled carbon finance. This would involve addressing several bottlenecks, including regulating the carbon market to ensure fair benefit sharing and environmental integrity, providing effective sector oversight, deepening policy implementation at the decentralized level, improving law enforcement, strengthening indigenous peoples' and community rights, and strengthening its monitoring, reporting, and verification system.

3.1.2. Livestock and agricultural production need to become climate-smart to increase productivity, resilience, and lower emissions

Agriculture is the principal economic activity in rural Colombia, but the stagnant performance of the sector is keeping rural communities from improving their income and wellbeing. Over the past five years, the agriculture sector has contributed 6–7 percent to Colombia's GDP (World Bank 2021a). Moreover, agriculture accounts for 60 percent of employment in rural areas and produces 60 percent of total food supply in the country (Uniandes 2021). Although agricultural employment in both urban and rural municipalities has been declining as a share of total employment, it remains high in comparison to other upper-middle-income countries. However, with its sluggish growth and stagnant productivity, the agricultural sector is not performing well enough to deliver the benefits that trade offers and is preventing many farmers from making ends meet. Colombia's total factor productivity (TFP) in agriculture is lower than the OECD average and that of comparable countries such as Peru, Mexico, Brazil, and Chile.²¹ Agricultural imports have outpaced exports, excluding coffee, and adversely affected the balance of trade in the agri-food sector.

Colombia's agriculture needs to become more sustainable and productive. Agriculture directly causes 21.6 percent of Colombia's GHG emissions, with 14.8 percent alone stemming from Colombia's large cattle-ranching sector, mainly via enteric fermentation and manure management. Agriculture, and in particular livestock, is also a major driver of land-use change including deforestation: as a result of its low productivity and weak law enforcement, the 71 percent rise in agricultural production between 2001 and 2021 (World Bank 2022g) mainly occurred by expanding the area under production (MADR 2019), at the expense of forests and other natural ecosystems. This generates a further 20.9 percent of national emissions (Government of Colombia 2022). Colombia's low TFP means that agriculture's land footprint has ample space for reduction without sacrificing production, and the use of inputs to production could also be made more efficient.²²

²⁰ This estimate is based on an average yearly carbon price at the midpoint between 0 and the price used in Streck et al.'s analysis. Adding the potential of agriculture and wetland management, the value would increase to US\$1.27 billion per year.

²¹ Colombia's total productivity factor in the agriculture sector between 1990 and 2020 was 18 percent, compared to 36 percent for the OECD average, 45 percent for Peru, 90 percent for Mexico, 110 percent for Brazil, and 142 percent for Chile (USDA 2023).

²² Growth in TFP occurs when farmers increase output using improved technologies and practices, such as advanced seed varieties, precision mechanization, efficient nutrient and water management, and improved animal care practices. Using agricultural inputs efficiently to generate more output, therefore, holds the potential to reduce agriculture's environmental impact and to lower costs for producers and consumers.

The scaled-up adoption of climate-smart agriculture (CSA)²³ could play a win-win role in Colombia's climate and development agendas. Although CSA is already being practiced in Colombia, in 2020, only 15 percent of agricultural production units used innovative technologies including CSA (Gaviria González 2022), and most CSA implementation efforts have remained at a pilot stage. This is due to a lack of public agricultural innovation services (research and development and extension),²⁴ as well as a lack of access to financial services and markets. To propel the adoption of CSA, it is essential to create an enabling environment that deploys such services at scale. Climate-informed investments in productivity could yield substantial development and climate benefits: The potential contribution to economic growth of improving agricultural productivity by 5 percent in Colombia is 10 times higher than the simple, business-as-usual expansion of the area under production through deforestation.²⁵ Moreover, investing one dollar in agricultural productivity yields nearly 1.5 dollars in profits as well as employment for the rural poor (Corredor 2016). Investments in agriculture and livestock also have job creation benefits that are higher than in most other sectors (111 and 103 direct jobs created, respectively, per US\$1 million invested) (Simas and Wiebe 2020). Commodities such as beef and dairy, rice, coffee, cocoa, sugar cane, and horticulture have the greatest investment potential in CSA because of their prominent role in Colombia's GHG emissions and their climate adaptation benefits.

Given the preponderance of the livestock subsector's weight in Colombia's land-use and GHG emissions, this subsector needs to become more climate-smart. A large part of Colombia's natural capital is used to raise cattle, with 91 percent of agricultural land serving cattle and other livestock ranching (FAO 2020). Colombia's Nationally Appropriate Mitigation Action for Livestock (NAMA Bovina), adopted in 2020, lays out emission reductions targets as well as a set of actions and CSA technology adoption pathways, but to reduce emissions in line with Colombia's climate goals, these would need to be scaled up dramatically: 16.3 million ha of livestock systems would need to be made sustainable, the expansion of pasture areas and herd growth would need to slow down, and an additional 3.2 million ha of agricultural land would need to be sustainably intensified. The CSA investment potential in the livestock sector is more than US\$1.4 billion, mainly in silvopastoral systems. Other promising CSA measures include fodder banks, rotational grazing, water management systems, and solar-powered milkers (IFC 2022). However, the adoption of CSA technologies in the sector has been low, and despite the investment potential, this subsector represents only a minor share of overall CSA investments.²⁶ Sizable public and private investments are required to transform the NAMA Bovina into actionable policies and investments that would reduce livestock emissions. While the livestock sector does not present quick mitigation wins—its potential for contributing to the NDC's mitigation goal is only 1.5 to 2.5 percent in 2030 even considering accelerated implementation—after 10 years it could represent 4.3 percent of Colombia's emission reductions, an important contribution, given its weight in Colombia's emissions matrix.

To overcome obstacles to CSA adoption, several coordinated sets of actions are required. Approximately 96 percent of agricultural production that occurs on converted lands serves domestic markets (Forest Trends 2022), suggesting that demand-side solutions, which will be needed to achieve net zero goals, need to be primarily domestic. However, in the short term, accelerating CSA adoption requires improving the alignment of public policies and programs to increase access to innovation, rural extension, financial services, and markets, in addition to general investments such as improved water and transport infrastructure and land rights. To achieve the overall goals of enhancing productivity, food security, inclusiveness, climate resilience, and environmental sustainability, the public and private sectors must work together to:

- » **Repurpose agricultural support toward promoting green innovation.** Currently, Colombia provides 88 percent of public support for agriculture via price interventions such as stabilization prices. This distorts prices and discourages technological improvements (OECD 2020b). Agricultural support should be repurposed toward promoting green innovation by providing public goods and services such as research and development, rural extension, and enabling more CSA financing. Such efforts will drive

²³ CSA is an integrated approach to managing landscapes and food systems that aims to simultaneously contribute to the following three pillars: sustainable increases in productivity, the enhancement of climate resilience, and reductions or removals of GHG emissions where possible.

²⁴ From 2010 to 2020, support to the agriculture sector allocated to the provision of public services such as research and development, rural extension, and agriculture financing accounted for 2 percent of total public support to the agriculture sector. Source: OECD (2020a).

²⁵ World Bank analysis based on Banerjee et al. (2021).

²⁶ Current CSA investments based on data from FINAGRO are around US\$198 million (based on 2021 figures for a 10-month period). However, 80 percent of this is concentrated in the avocado subsector, while cattle, a subsector with much greater land coverage, represents only a minor share. Figures should be considered as a directional, conservative, estimate average for a 10-year period. Source: IFC (2022).

the structural changes required to improve productivity, long-term competitiveness, and tax receipts, and to reduce poverty, GHG emissions, and land requirements (Gautam et al. 2022; Pardo Martínez and Cotte Poveda 2021). Bridging the connectivity and digitalization gaps between rural and urban areas, and increasing irrigation coverage where appropriate, would also further strengthen the sector's performance.

- » **Strengthen the agricultural innovation system to mainstream CSA and livestock innovation technologies and practices.** It is essential for Colombia to invest in development, validation, and scalability of technologies that improve productivity and allow for more efficient use of production factors while preserving natural resources and lowering GHG emissions. These efforts must be aligned with extension services to ensure that technologies flow smoothly from incubation to field scalability. Significant private investment opportunities also arise in agroforestry systems, irrigation and water management, and post-harvest infrastructure to reduce food losses, and energy efficiency improvements along agricultural value chains (IFC 2022).
- » **Foster financial innovation to spur technology adoption and improve risk management.** Farmers face a lack of financial services that properly consider the requirements of CSA technologies, impeding their uptake. It is essential to adjust the current portfolio of credit and risk management instruments to meet the investment needs associated with technology adoption while also increasing the ability of all farmers (small and large) to leverage their investment through credit. This includes longer grace and financing periods that are adapted to crop cycles, and credit incentives for sustainable changes in land use, as well as technical assistance tied to financing. The government could partner with financial institutions, including microfinance institutions that have a large outreach, to expand access to credit in rural areas. It could also set ambitious targets for second-tier banks to expand CSA lending and to include climate criteria in lending decisions. Expanding the provision of guarantees and of agricultural insurance to improve risk management would also be required. Increasing access to agricultural insurance is particularly critical among smallholder producers. To increase uptake, the government could further its efforts to raise awareness about the benefits of insurance among small farmers. Partnerships among financial institutions, input providers, extension services providers, and market off-takers to integrate digital solutions into producers' and businesses' practices could be promoted. These would require addressing connectivity gaps in rural areas and developing agricultural and weather databases and applications for insurance purposes (IFC 2022).
- » **Improve land information systems and administration, as well as law enforcement:** Without these, increased agricultural productivity risks creating additional pressure on natural ecosystems because productivity improvements create economic incentives for further agricultural expansion. Implementing the recommendations in Section 3.1.1 is therefore vital to enable the success of the above measures while avoiding the unintended negative effects of increased agricultural productivity.

3.2. Infrastructure development for a low-carbon and resilient transition

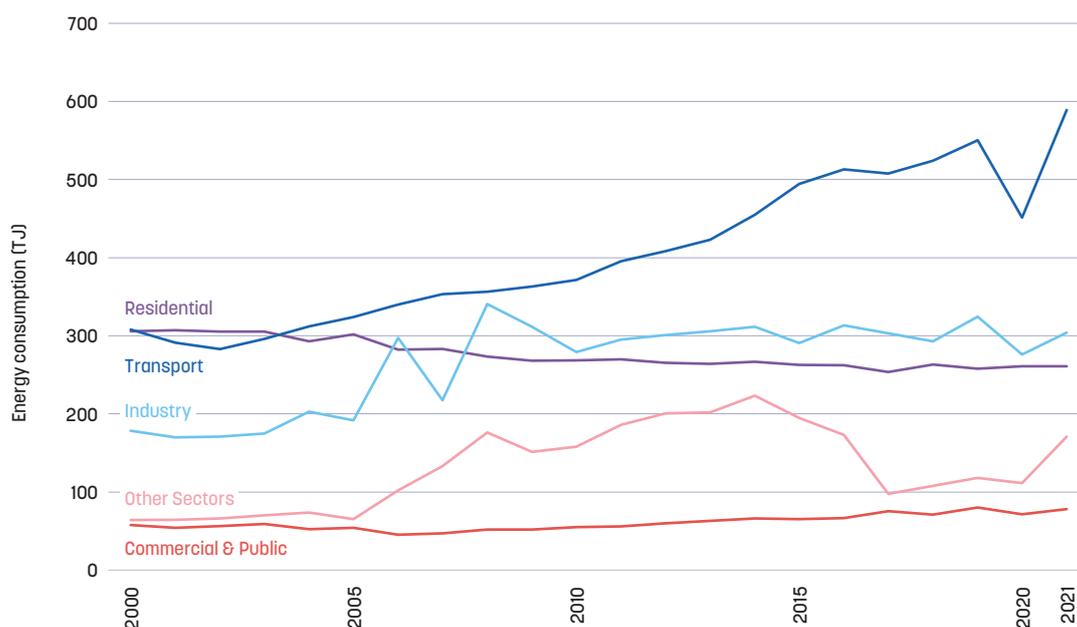
Main messages

- * Investments in climate adaptation of transport, energy and water infrastructure are needed to close current infrastructure gaps, and would benefit predominantly vulnerable regions.
- * The decarbonization of the energy mix will require economy-wide electrification, efficiency measures, and investment in new, low-carbon, electricity generation.
- * Beyond electrification, decarbonizing Colombia's economy requires a strong commitment to transforming the transport sector.
- * A net-zero and resilient transport and energy sector would require an additional investment of US\$47 billion, resulting in economic and social benefits in excess of US\$32 billion over 2023–2050.

Colombia's infrastructure development is at the heart of its development and climate agendas. The country needs to close infrastructure gaps to continue its economic and social development but needs to do so in a transformational manner to protect those investments from the impacts of climate change while also achieving its emission reduction goals. Brichetti et al. (2021) estimate that closing the existing gap in Colombia will require US\$100 billion of investment from 2019 to 2030—US\$47 billion for transport, US\$27 billion for energy, US\$20 billion for water, and US\$6 billion for digital infrastructure—to achieve the country's sustainable development goals by 2030. However, this value does not consider additional needs to make the infrastructure climate-resilient, nor the investment needed to dramatically shift the upward-trending emissions pathway, especially of the transport sector (Figure 3.2). This CCDR takes existing analyses further to fill these knowledge gaps.

Resilient and low-carbon infrastructure will boost social inclusion. Climate-resilient infrastructure—roads, electricity, digital and water—is especially important in lagging regions to reduce economic inequality and social exclusion, and even more so in conflict-affected regions. Investments in public transport and active transportation can significantly benefit medium- and low-income populations and disadvantaged groups (Guzman et al. 2023) by expanding their access to jobs and economic opportunities, reducing road accidents, which are estimated to annually injure more than 770,000 people and cause 6,000 deaths and are the leading cause of death in Colombia for the 5–29 age group (Romero et al. 2018). It would also create safer and healthier cities, significantly reducing air pollution in a context where 15,000 deaths a year are associated with air pollution, especially among the elderly, children, and people with existing respiratory and cardiovascular conditions (INS 2018).

FIGURE 3.2. The rise in energy consumption has been driven mainly by transport and industry



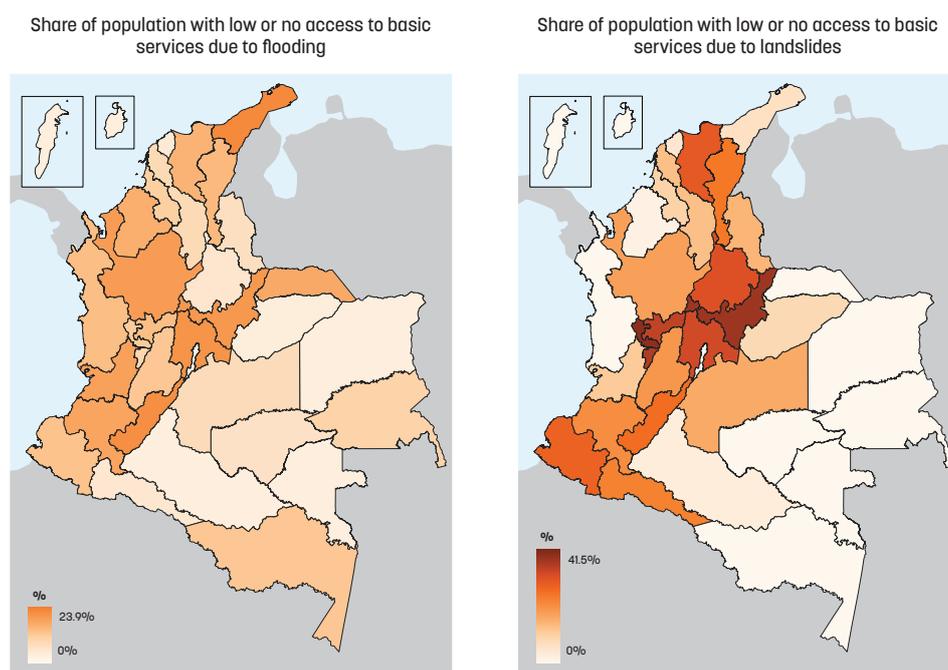
Source: UPME (2022).

3.2.1. To ensure that development gains in lagging regions are sustained, investments in climate-resilient infrastructure are needed

Colombia needs to significantly boost investment in climate-resilient roads to ensure that climate impacts do not undermine gains in connectivity and access to basic services (health, education, markets). Because of poor rural road conditions, low road density, and limited network connectivity, some 10.6 million people (22 percent of the population) experience low accessibility (60 minutes travel time or more) to basic services such as provincial hospitals, higher education, or public administration. This population is concentrated in peripheral departments such as Vichada (73 percent of population with

low access), Chocó (53 percent), and Putumayo (52 percent) (Figure 3.3). Climate-induced impacts disrupt the road network, with an estimated 2.2 million and 3.4 million additional Colombians losing access due to 50-year return flooding and landslides, respectively, in the absence of climate-resilient rural roads. That is equivalent to an average of 230,000 people every year. Climate projections indicate that those numbers could increase by 60 percent by 2050 and 140 percent by 2075. Investing in the adaptation of vulnerable rural roads is critical for strengthening resilience and promote social and economic growth, especially for departments with high poverty and low access (World Bank 2023d). However, in forested parts of the country, rural road investments need to carefully consider deforestation risk by applying green road infrastructure principles (Government of Colombia, WWF, and FCDS 2020).

FIGURE 3.3. Climate-induced flooding and landslides disrupt road access to basic services, affecting up to 24 and 41 percent of the population, respectively, predominantly in poor, peripheral departments



Source: World Bank (2023d).

In addition to resilient rural roads, climate adaptation of critical primary roads can generate large economic benefits but will require increasing private financing, building on already ubiquitous public-private partnerships (PPPs). The adaptation investment needs of critical primary road sections to minimize the impacts of landslides, floods, and hurricanes are estimated at US\$675 million by 2050²⁷ (World Bank and IFC 2022). These investments would reduce direct asset damage and operating and maintenance needs, and generate multiple co-benefits for the environment, communities, road operators, and the government by (i) reducing freight transport costs as a result of road closures, (ii) reducing the risk of isolation of entire communities, (iii) improving ecosystem services through the use of nature-based solutions, and (iv) improving the safety of the primary road network (which is 47 percent-concessioned) by reducing the number of accidents due to natural hazard events.

These types of investment have a demonstrated ability to mobilize private capital in Colombia because the current legal and regulatory environment (4G and 5G PPP programs) provides a solid base for mainstreaming climate adaptation in the road sector. However, to further increase private sector financing, Colombia could (i) improve the regulatory environment to foster investor confidence by

²⁷ Net present values in 2023 discounted at 6 percent.

providing clarity on the roles and responsibilities of stakeholders, legal and institutional frameworks, and mechanisms to finance resilience measures; (ii) together with private sector input, update and further develop a pipeline of bankable brownfield projects, incorporating climate risk assessments into them and providing information on the economic, social, and environmental benefits of the projects; (iii) operationalize blended finance mechanisms—including climate-specific concessional loans, guarantees, and equity investments to reduce the cost of capital—by which the government could leverage public funds, to reduce risks and increase returns for the private sector; and (iv) employ climate finance instruments to incentivize private investment in climate resilience and adaptation. For infrastructure investors, examples of such climate finance instruments could include (i) sustainability-linked finance products (for example, bonds and loans) for transport infrastructure projects that provide pricing incentives tied to the achievement of specific outcomes, and (ii) concessional blended finance incorporating performance-based contracts that link payments to resilience outcomes (for example, reduced flood risk). For public sector-funded infrastructure programs, the instruments could include (a) catastrophe bonds for infrastructure that transfer climate-related risks to capital markets, and (b) concessional green funds.

Maintaining a high utilization of hydropower, combined with increasing wind and solar energy production and improved transmission infrastructure, will create a strong and climate-resilient power generation system. Climate trends in Colombia point toward slightly higher availability of water for hydropower nationally. In scenarios analyzed by the World Bank (World Bank 2023c), adapting to this slightly increased availability by including hydropower in system expansion would produce net benefits, both in terms of reduced investments and of reduced overall net-present costs. Though water availability is not expected to increase in all basins, the distribution is such that average energy inflows increase across the system without significant negative impacts on interannual variability. While *El Niño* years are still expected to considerably decrease hydropower generation, deficit risks do not increase substantially. This is due to the significant shares of non-hydropower renewables (notably wind and solar) that are expected to be deployed in the coming years as part of the least-cost solution to expand generation, and the complementarity of these technologies with hydropower on time scales relevant for the operation of the Colombian system: wind and solar have lower, long-term variability than hydropower, whereas hydropower can be dispatched to counteract their variability in the very short term. The expansion of the electricity generation and transmission system will continue to rely on this complementarity between different renewable sources, leveraging auctions and other policies already used in Colombia, but will require the increased capacity of both public and private sector actors in terms of planning, supply chain, and workforce needs, project preparation and implementation capacity, and the availability of financing.

A climate-resilient electricity and digital telecommunications system has strong social inclusion impact by helping to increase access for those who remain disconnected from the grid, or those who have extremely low quality of service. Although electricity coverage is 97 percent, some 500,000 households still do not have access to electricity, with nearly 170,000 of those in areas where there is no grid (UPME 2019). There are major regional disparities in infrastructure access: in La Guajira Department, for example, only 70 percent of the population has electricity service.²⁸ Similar gaps can be observed in digital telecommunications services infrastructure: Amazonas, Vaupes, and Vichada have penetration rates below 5 percent, less than one-tenth of the national average of fixed broadband households' penetration, while Bogotá and Antioquia have 76 percent and 63 percent, respectively (DANE 2021).

Reliable access to utilities such as energy, digital, or telecommunications services are essential for increasing quality of life and citizen participation, and are a central factor in improving productivity, making it a prime enabler of climate resilience and economic development. The proposed Non-Conventional Renewable Energy (NCRE) project deployment (with solar or wind) and electric grid expansion can help increase energy access with the lowest possible environmental impact, while increasing the resilience of electricity generation in the context of climate impacts. In addition, it presents opportunities to improve livelihoods by supporting clean cooking, helping Colombians to shift from wood and charcoal use to cleaner options with lower impacts on natural resources and health. Finally, it is worth

²⁸ World Bank calculation based on UPME (2019) and DANE (2018).

noting that the quality of electricity services is uneven throughout the country, with some distribution companies reporting losses of up to 30 percent and service interruption frequencies three times higher than the national average (World Bank 2023g).

Ensuring water security through investment in water supply, sanitation, and irrigation will stimulate economic and social development in lagging regions while building resilience in the context of climate change. Colombia is one of the most water-rich countries of the world. Nevertheless, the uneven distribution of the population creates a mismatch between freshwater availability and concentrated demand, which, coupled with pollution, land-use change, and the highly variable rainfall regime, makes water resource management a critical challenge. Rising temperatures are already leading to rapidly shrinking Andean glaciers, a key headwater source. In already water-stressed areas, in particular in the center and north of the country, even the slight declines in precipitation predicted by various climate scenarios would be keenly felt. Investments in water supply, sanitation, and irrigation should therefore be prioritized, especially in lagging areas with existing water stress, with joint positive effects for public health, human capital, and climate resilience. Additionally, in a fragmented institutional environment, rationalization of water supply and sanitation services can yield positive efficiency gains in terms of financing, service quality improvement, and water source protection (World Bank 2020), increasing the resilience of service providers who may face increased investment costs in a climate change scenario. In this context, the focus of the most recent development plan on planning around water is a useful development.

3.2.2. The transport sector requires a large transformation to align with net-zero commitments

Colombia has set up an ambitious transformation agenda for the transport sector aligned with net zero, and such a transformation will produce large social and economic benefits. To play its role in reaching net zero, Colombia's transport sector needs to include mitigation measures focused on modal shift, energy sources, and technology. Current transport emissions are generated mainly by road transport (85 percent), which in turn are split 65/35 percent between passenger and freight transport. For freight, reaching net zero requires, among other things, increasing the participation of rail in freight operations from 7 percent to 20 percent by 2030 and 42 percent by 2050. In urban environments, it requires increasing the share of urban trips by metro, rail, and cable cars from 0.2 percent to 2 percent, and of non-motorized transport (walking and biking) from 1 percent to 15 percent, implying an expansion of cycling lanes to 1,750 km. Over 2022–2050, this ambitious transformation will generate co-benefits on the order of US\$23 billion, including health benefits from increased physical activity, reduced air and noise pollution, fewer traffic-related deaths and injuries, and less congestion in major urban areas (World Bank 2023e).

To advance the decarbonization of the transport sector, Colombia should build on existing progress by focusing on electrifying its public transport systems and continuing successful modal shifts toward active transportation. Colombia is recognized as a global leader in bus-based public transport, with seven of its cities sporting mass urban transport systems (bus rapid transit, cable cars, and metro in Medellín) that move 17 percent of all Colombians. When fully operational in 2025, Bogotá's 1,485 electric buses will likely constitute the largest electric bus fleet in the region. Further electrification of buses should be the priority as it is already financially viable and results in improved air quality and health benefits (Briceno-Garmendia, Qiao, and Foster 2023). By 2030, 67 percent of public transport and 55 percent of all cars would need to be electric. Furthermore, electrifying public transport serves as a learning arena for transport segments that are harder to decarbonize, such as private vehicles or trucking. Although Colombia had 8,300 registered electric vehicles, 2,400 of which are cars, as of June 2022 (MT 2022) the country is not on track to achieve its objectives of 600,000 electric cars by 2030. The government should invest in setting up incentives for the deployment of a public-private, widely available, and robust charging station network, as this has been proven to be the most cost-effective measure to ramp up electrification in the medium term (Briceno-Garmendia, Qiao, and Foster 2023). Furthermore, Bogotá is a regional leader in non-motorized transport, with 6 percent of all trips made by bike because of strong policy commitments, infrastructure investment, and severe congestion for private vehicle users. In fact, non-motorized modes

of transportation (walking and biking) are the most cost-effective mitigation measure in Colombia's NDC (VITO and Uniandes). A deeper shift toward this mobility should be prioritized but will depend on the supportive urban planning.

Although Colombia has pioneered private sector participation in the delivery of public transport services, improving concession models while keeping in check public resources required to cover operating expenditures will be critical to increase public transport use and achieve fleet electrification. Since 2016, increased motorization rates and the emergence of informal modes of transport have led to stagnant mass transit ridership in most Colombian cities except for Bogotá and Medellín (Gómez-Lobo 2020). This has resulted in a negative structural financial outlook for urban public transport systems. In response to that outlook, Bogotá is separating fleet provision from the operation obligation, thus isolating the risks taken by concessionaires and their financiers from those associated with implementation, demand, or performance. These improved business models might enable a successful transition of diesel fleets to low-emission vehicles by improving their bankability but are likely to demand an increased amount of public funding, as Bogotá's case shows. For these business models to work, binding commitments are required from local governments to cover the structural farebox ratio deficit. Second, the contractual financial obligations of public sector entities need to be enforceable in the event of non-compliance.

In addition to significantly speeding up the implementation of a bold vision for multimodal transport infrastructure, the decarbonization of freight transport requires a considerable overhaul to the policies that govern trucking sector emissions. The road freight sector, which has a de facto modal monopoly on freight—92 percent of freight is road-based, excluding oil and coal—underperforms regional peers in terms of emission standards, fleet modernization, fuel technologies, intermodality, and advanced logistics management. Only 12 percent of the trucking fleet has engines that meet Euro IV or higher emission standards. Although government efforts for the next decade prioritize fluvial and rail modes in the new 5G, public-private partnership pipeline program, with US\$1 billion of capital expenditures required in the first two waves, modal shift is not expected to deliver significant emission reductions before 2032. In this sense, bolder policy and investment measures in the trucking sector should target overall emissions.

A vision to decarbonize Colombia's primarily road-based freight sector should focus on implementing a Low-Carbon Road Freight Program that aims to reduce the sectors GHG emissions by 20 percent by 2032. Such a program should include policy and investment measures that speed up (i) the adoption of strict emission standards for new trucks entering the market, to at least Euro V, to ensure that vehicle replacement leads to the introduction of cleaner, more efficient alternatives; (ii) concessional funding (through the recently created fleet replacement fund) to incentivize fleet modernization using a combination of tax incentives, concessional loans and subsidies, particularly for Euro VI complying units, trucks powered by compressed natural gas (CNG), and electric and hydrogen pilots; (iii) the adoption of alternative sustainable fuel technologies such as electric-, hydrogen fuel cell-, and bio-fuel-powered units; (iv) the deployment of infrastructure for alternative fuels, including charging stations for trucks, hydrogen refueling, and biodiesel blending facilities; (v) in coordination with the private sector, the adoption of smart, advanced logistics management, including route optimization, backhaul and deadheading minimization, driver training for efficiency and proper maintenance, and (vi) the improvement of logistics infrastructure, including the addition of freight corridors, expansion of intermodal infrastructure, and improvement of the road network to reduce bottlenecks and congestion.

3.2.3. The energy sector requires investments in renewable energy, improved electricity transmission, and efficiency measures

Colombia needs an ambitious electricity sector expansion that requires aligning policies, planning and regulations with its decarbonization goals. Current government energy planning foresees electricity covering between 20 percent (PEN2020) and 70 percent (E2050) of all energy needs by 2050 (MME 2021b). However, the most credible pathway for achieving net zero will require coverage of 70 percent. To reach this goal, electricity generation by 2050 would need to be up to five times as high as currently planned for

that same year. This, in turn, will require renewable energy generation capacity to grow from a baseline of 3 percent per year to 18 percent per year from 2023 to 2050 (UPME 2020). This would represent a challenging expansion rate of the electricity generation and transmission systems, straining the capacities of both public and private sector actors in terms of increased supply chain and workforce needs, project preparation and implementation capacity, and availability of financing. Enabling this transition will require, among other things, aligning electricity sector policies, planning, and regulations with the ambitious transformation scenario; transmission planning that considers future renewable energy requirements, even before new connection requests are issued; wholesale market regulation that better reflects the grid services provided by renewables; and social and environmental processes that engage communities at an earlier stage.

Scaling up energy efficiency can provide benefits to the whole economy and build on ongoing successful private sector and green finance initiatives. Since 2015, a combination of government policies and incentives (energy efficiency law, green building code, and tax incentives), the promotion of green building certifications by the private sector, and innovative green finance instruments has allowed the development of a thriving ecosystem for energy efficiency in the buildings sector. The Colombian Chamber of Construction, a private sector association, spearheaded the promotion of investments in sustainable construction with the rollout of Excellence in Design for Greater Efficiencies (EDGE), a green buildings certification program to reduce energy, water, and energy used in materials. This has become an important driver for the adoption of sustainable construction practices. Estimates of EDGE-certified floor space in the country are at about 27 percent of the new build in 2022, a high penetration rate for an internationally recognized certification in emerging markets. In addition, the Colombian Chamber of Construction and the Sustainable Construction Council promote the use of incentives and support for technical capacity at the municipal level to further accelerate the adoption of sustainability criteria in construction projects. As of 2022, five commercial banks offered green mortgages and/or some type of financing for green construction. This provides developers and end customers with attractive rates to finance their projects and homes. The Net Zero Carbon Building Accelerator, led by the Ministry of Environment and the Ministry of Housing, with strong participation from these private sector organizations and local government representatives, has developed a national roadmap to support the transition to net-zero carbon buildings. The roadmap provides policy and regulatory recommendations for financial institutions, the real estate sector, and local governments to accelerate progress. Although challenges remain, specifically in the decarbonization of building materials (for example, cement), in production, and in technological innovations, this successful public-private dialogue platform for the joint definition of challenges, solutions, and milestones to achieve net zero could be a model for other sectors to boost the pace at which investments in mitigation and adaptation are made. Scaling up energy-efficiency policies and regulations across the economy (including in the residential, industry, agriculture, and service sectors) to the level of the Latin America region's best performer—Mexico²⁹—could reduce Colombia's energy expenditures by around US\$600 million per year, equivalent to 3 percent of current expenditures (World Bank 2023h).

Low-carbon hydrogen is a promising medium-term solution to decarbonize hard-to-abate sectors such as industry, mining, and long-haul transport uses. Even though energy efficiency and electrification are a priority for the decarbonization of the energy sector, Colombia needs to develop viable, long-term alternatives for the decarbonization of hard-to-abate sectors. Colombia's abundant renewable electricity resources can help achieve both objectives, in line with the country's "Hydrogen Roadmap," which included a competitiveness assessment that concluded that the country has the potential to compete with countries like Chile and Australia in producing some of the cheapest green hydrogen globally (US\$1.7/kg by 2030) (MME 2021a). The industry, mining, and hard-to-abate transport uses (mainly in long-haul freight) sectors could reduce their carbon intensity partially by integrating low-carbon hydrogen into their processes while helping to accelerate and scale up the integration of hydrogen technology in Colombia. The country has the necessary elements—stable macroeconomic environment, conducive policies, excellent wind resources in La Guajira, significant domestic market potential—to become a competitive producer of low-carbon hydrogen. Regulations for the production and use of hydrogen need to be drafted

²⁹ Using 2019 RISE scores (rise.esmap.org), which measure the level of advances in issuing and implementing energy-related policies.

and implemented, including certification mechanisms for low-carbon hydrogen, standardization, and homologation of components in the hydrogen value chain, and regulations for transport, storage, and distribution. The development of the offshore wind industry in Colombia, coupled with the development of green hydrogen production and the derivatives industry, presents an opportunity to not only promote national decarbonization but also create new export markets.

Decarbonizing the energy sector will require additional investments between US\$30 billion and US\$60 billion by 2050, necessitating a substantial mobilization of the private sector. To meet Colombia's mitigation goals, renewable electricity needs to reach 24 GW, and green hydrogen at least 2 percent of industrial energy, by 2030. Long-term forecasts for the power sector estimate total additional investment needs between US\$30 billion and US\$60 billion to reach net zero goals by 2050, depending on demand scenarios and decarbonization pathways, estimated by World Bank (2023e) and UPME (2020) respectively). While Colombia has access to international markets, it still needs to fully leverage its domestic private financial sector to provide long-term financing to cover the investment needs. Given the nature and level of maturity of the renewable electricity industry, for example, these types of investments are generally financed through project finance schemes. Nevertheless, Colombia could expand the availability of bankable, long-term, power purchase agreements either through new auctions or other mechanisms that help create a market for these contracts. Recent innovative government efforts such as double-sided renewable generation auctions, together with a stable regulatory environment and continued work to level the playing field for renewable energy, could go a long way to attract private developers.

3.3. A people-centered approach to managing climate impacts and the low-carbon transition

Main messages

- * Current social protection systems do not offer enough protection to vulnerable households in the event of climate shocks and would benefit from becoming more adaptive.
- * Meeting Colombia's 2030 decarbonization goal would, on balance, create approximately 347,000 jobs. However, there will be winners and losers, and developing comprehensive social programs to ensure a just transition will be critical for the social acceptability of Colombia's low-carbon transition, with a focus on the geographical areas most at risk of significant job and economic losses, such as the coal mining regions of La Guajira, Cesar, and Boyacá.

An equitable and just transition is a precondition for ensuring that climate mitigation and climate impacts do not deepen inequalities, and for maximizing the development potential of adaptation measures, especially given Colombia's high underlying inequality. Colombia's Social Protection System is insufficiently prepared to respond to shocks (World Bank 2021b), and in a country where a substantial number of jobs depend on hydrocarbon industries and other emission-intensive sectors, transition risks need to be managed.

3.3.1. Improvements in social protection programs are needed to protect the most vulnerable in the event climate shocks

Although the social protection system plays a mitigating role against shocks, it is not yet sufficiently robust to cushion the impacts of shocks on all Colombians. During the recent COVID-19 shock, it is estimated that government emergency transfers mitigated around a quarter of the negative impact on poverty. In the case of a severe climate-related shock, 45.5 percent of households in the most affected departments would not be covered by existing social assistance arrangements (Table 3.1), while 11.4 percent of the newly poor would need new coverage. In such a case, it is estimated that poverty and inequality

would increase, and that around 3 million poor people would fall deeper into poverty. For instance, in poor departments like Magdalena, with its baseline poverty rate of 53.5 percent, total and extreme poverty would increase by 3 and 4 percentage points, respectively (Dávalos et al. 2023).

TABLE 3.1. Almost half of all households in climate-vulnerable departments are not covered by a social assistance program

	Any Social Program	Más Familias en Acción	Jóvenes en Acción	Colombia Mayor	Ingreso Solidario*	VAT Compensation
Social program coverage of climate shock (2019 baseline microdata, simulated programs)						
All Households	39.3	12.7	0.4	7	20.1	13.4
Households in the most affected departments	54.5	21.1	0.6	8.7	25.7	21.8
Rural households	62.2	25.3	0.4	12.7	25.5	26.9
Newly poor households	77.7	25.4	0.8	11.2	42.9	28.4
Newly poor in the most affected departments	88.6	33.2	0.4	10.8	47.2	36.1
Newly poor and rural households	95.4	34.9	0.8	13.8	49.2	41.9

Source: World Bank estimates based on DANE-GEIH-2019.

Note: Results simulate programs such as *Ingreso Solidario* (IS) and VAT Compensation based on rules of entrance into the programs using GEIH-2019.

*IS ended in December 2022 and a new design for the social protection system is being prepared; with the elimination of IS, the number of uncovered households will increase.

To respond to climate shocks, the government needs to build on existing efforts to make the social protection system more adaptive. The government has started adapting social protection programs by implementing incipient measures to cope with the COVID-19 pandemic and extreme climate events. These include horizontal (coverage) and vertical (amount) expansion of benefits as well as innovations in targeting and payments delivery. However, social assistance programs require (i) significantly improving the coverage and amount of benefits, (ii) adapt productive inclusion programs to include climate resilience measures; (iii) innovating the delivery chain of social protection programs (from targeting to case management); (iv) creating counter-cyclical financing instruments and redirecting resources toward areas prone to climate disaster risks, where the poorest are concentrated; (v) strengthening of early-warning systems and the interoperability between the social registry and the DRM registry, and (vi) strengthening inter-institutional coordination between the social protection and DRM sectors.

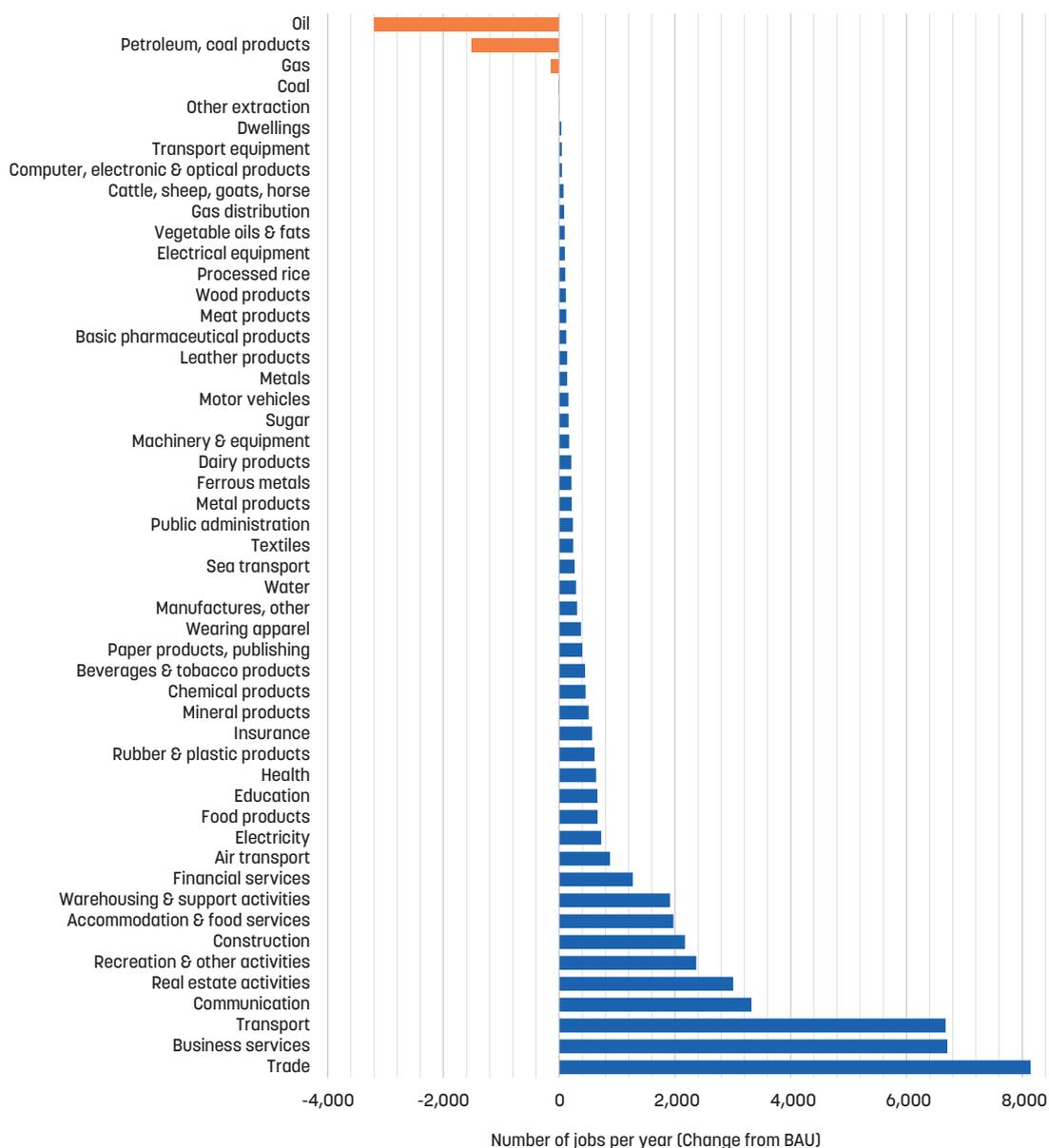
3.3.2. The low-carbon transition would on balance create jobs but also increase the vulnerability of certain worker groups

Meeting Colombia's NDC mitigation target has the potential to add approximately 347,000 jobs (or 1.6 percent of the 2022 employment level) between now and 2030 relative to a business-as-usual scenario, but the sector and poverty impacts will vary (World Bank 2023b).³⁰ The rate of absorption of displaced workers into expanding sectors will depend on the relevance of these sectors within local economic activity, the availability of similar jobs in local labor markets, and the capacity of firms to upgrade their productive capabilities. Two sectors expected to contract because of the transition are coal mining and petroleum extraction, both of which are mostly concentrated in the departments of Boyacá and Santander, respectively. Although many other sectors will grow as a result of the transition (Figure 3.4), they will not necessarily reemploy workers laid off in the contracting sectors. For example, in Boyacá, at-risk coal mining jobs are less likely to be absorbed by expanding sectors because firms in those sectors provide opportunities in occupations with different skill requirements, limiting the transition of these at-risk workers. By contrast, in Santander, the absorption capacity of petroleum mining jobs is higher for all at-risk jobs, and even more

³⁰This analysis considers only the effects of pursuing Colombia's NDC mitigation goals but does not factor in impacts from global decarbonization trends, such as reduced demand for oil and coal.

so for occupations that are easier to re-skill, because firms in the expanding sectors provide opportunities with skill requirements that are more similar to those in the at-risk occupations, especially for workers that rely more on manual skills, who can be more easily re-trained for similar available job opportunities. Finally, increasing the competitiveness of expanding sectors through the upgrading of firm and entrepreneurial capabilities can lead to higher rates of reemployment of workers who are in jobs at risk. For example, a 5 percent productivity increase in expanding sectors in Santander could result in the full absorption of workers from some occupations that are at risk in petroleum mining, such as security guards. However, the ability and willingness of workers to transition into new employment opportunities also depend on personal, community, and cultural factors.

FIGURE 3.4. The trade, business services, transport, and communication sectors will see the largest net job creation from a low-carbon transition

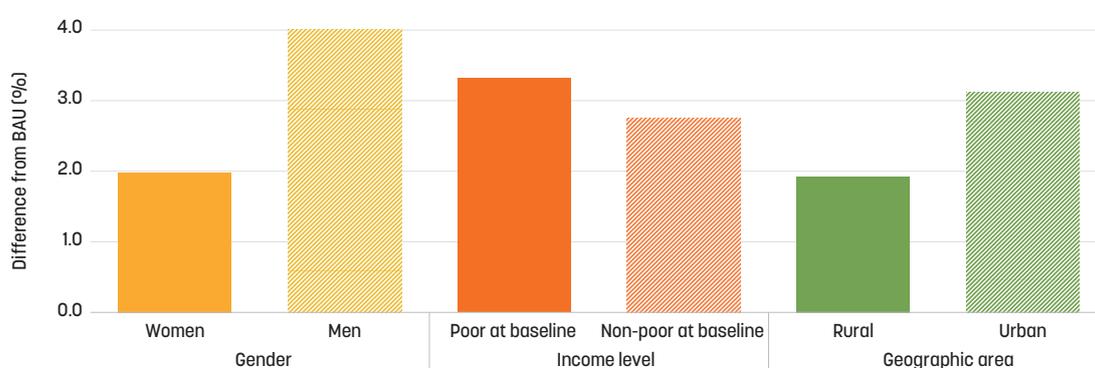


Source: World Bank (2023b).

Note: This figure reports the average annual net job creation by sector from the adoption of economy-wide mitigation measures to meet Colombia's NDC targets by 2030 relative to the business-as-usual scenario. The simulation is based on a methodology that uses Colombian household survey information (GEIH). It considers demographic characteristics such as geographical area, poverty level, gender, education, and sector of activity. It does not include informality status.

The decarbonization transition would lead both to more job-to-job transitions and to higher non-employment-to-employment transitions. Although the transition creates more new jobs for both men and women, because of persistent job inequalities in the sectors with the most job gains (that is, transport and communication), men may gain more new jobs relative to women (Figure 3.5). The poor are most easily absorbed into sectors that hire larger shares of low-skilled workers, such as trade, transport, and communications, where they represent 36 percent of new entrants. By contrast, the poor benefit less from job expansion in high-paying and predominantly formal sectors, such as high value-added services (that is, finance), where they represent 23 percent of new entrants. On balance, as trade, transport, and communications are expected to expand the most in a low-carbon transition, more new jobs are created for poor workers than for non-poor workers. Finally, the share of rural workers ranges between 5 percent in construction and 20 percent in industry and mining. Due to the declining number of jobs in mining under the decarbonization scenario, growth in urban jobs will outweigh growth in rural jobs.

FIGURE 3.5. The low-carbon transition will create more jobs for men than women, more for the poor than the non-poor, and more in urban areas than in rural areas



Source: World Bank (2023b).

Note: The figure shows the average annual percentage difference of new job takers under the mitigation scenario relative to the business-as-usual scenario. Job takers include workers who transition from employment to another employment, and from non-employment to employment.

The transition of coal mine workers as a result of coal phaseout programs poses particular challenges for Colombia. The experience of other countries such as the US and Poland offer lessons that can help guide Colombia's transition, including these six: (i) the transition may take a long time as coal assets are developed over many decades, cultivating links across regional and national economies, (ii) the uncertainty around commodity prices makes it difficult for communities to adjust for the "natural resource curse" because prices affect both the willingness and the capacity to diversify into other industries, (iii) transition assistance programs targeting formal mine workers usually do not meet the needs of informal workers in and around the mines, (iv) remoteness and the small local market sizes of coal-producing regions are mutually reinforcing impediments to transition, (v) the advantages of inducing voluntary job separations through generous compensation to miners are offset by the risk of doing long-term damage to local economies if prolonged income support further distorts local wages or former miners permanently exit the labor force, and (vi) economic diversification is essential and its planning and resourcing require support from both local and higher levels of government (World Bank 2021d; Ruppert Bulmer et al. 2021).

Managing the economic and social impacts of the shift away from coal in Cesar, Boyacá and La Guajira departments should be a priority. It should be guided by a comprehensive, provincial development strategy developed and jointly owned by the government and its partners. The roadmap should be rooted in social and economic analysis to determine new opportunities that build on the comparative advantages of each department, such as the one already prepared for La Guajira (Dobbin, Marquez, and Rietbergen-McCracken 2021).

A well-thought-out policy program may facilitate the just transition of jobs. The design of policies that promote Colombia's just transition to a low-carbon economy should consider factors such as economic activity, geographical location, and occupational composition, and promote the reabsorption of workers

into the labor force through labor supply and labor demand channels. Though it is beyond the scope of this CCDR to propose a detailed coal transition roadmap, international experience with coal phase-out programs (Stanley et al. 2018) suggests that public policies and programs should consider the following:

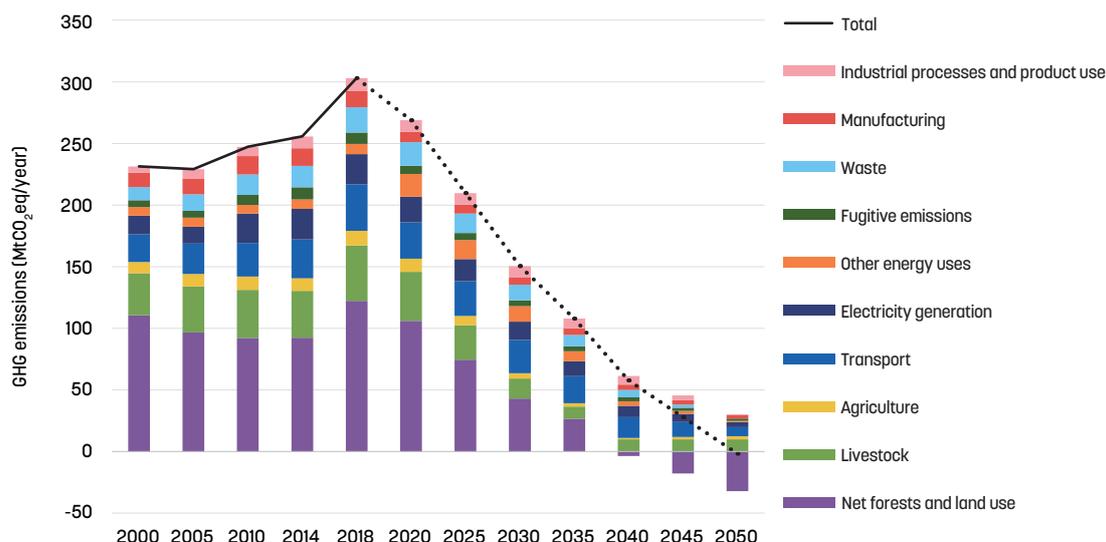
- » **Training and reskilling programs will facilitate the reinsertion of displaced workers into job opportunities, especially for low-skilled workers.** This should include education programs and skills training, including investments in reskilling for the green transition and in STEM—for example, renewable energy or energy-efficient technology—and in facilitating school-to-work transitions, with specific programs to overcome gender gaps in economic opportunities. This would equip workers with skills relevant to new job demands.
- » **Compensatory transfers and insurance programs can provide a safety net for workers as they search for new job opportunities.** This can lead to better job matches between workers' skillsets and firms' skill requirements because such a safety net gives a displaced worker more time to search for a suitable job. Compensatory transfers can have a particularly beneficial impact on workers in high-skilled occupations because the reallocation possibilities of such workers into other well-paying jobs are more limited.
- » **Facilitating the voluntary spatial reallocation of workers may improve outcomes as job opportunities in expanding industries may not be concentrated in regions where job losses are concentrated.** The capacity of expanding industries to absorb displaced workers may be limited in some departments but higher in others. Designing a policy that facilitates the voluntary spatial reallocation of workers may lead to welfare-improving outcomes. However, its design will need to consider many factors, including the removal of existing mobility barriers, and ensuring that relocated workers are politically, economically, and socially integrated and protected in their new destination communities.
- » **To strengthen the just transition, policy programs should consider addressing the gender gap.** Although a just transition may expand the number of job opportunities, the gender gap in job opportunities within expanding sectors may very well result in fewer women than men taking these jobs. Policies should promote the higher participation of women in expanding sectors in which their participation is relatively low, such as transport and communication.
- » **In sectors with climate-change mitigation measures, nurturing entrepreneurial capabilities and fostering the technological upgrading of firms can raise their competitiveness and help reap the benefits of the higher demand for the products of such sectors.** Policies that promote higher innovation in green technologies—for example, funding for R&D and support for the development of new products—and stronger linkages between firms and research institutions (for instance, through technology transfer offices) will strengthen and catalyze the entrepreneurial ecosystem in sectors that will expand during the transition. Additionally, policies that anchor firms in expanding sectors due to the climate transition into sustainable global value chains has the potential of creating jobs for displaced workers.

3.4. A representative 2050 resilient net zero pathway (RNZP) for Colombia

Colombia can theoretically achieve its 2050 net zero emissions target, but this will require genuinely transformative efforts (Table 3.2). While AFOLU currently constitutes the largest source of emissions, robust economic growth will lead to substantial increases in energy-sector CO₂ emissions in a business-as-usual scenario. Hence, although near-term efforts may focus on the AFOLU sector, a longer-term strategy must address potentially rapidly growing energy-sector emissions to prevent lock-in effects. The transformation will require deep decarbonization of the energy sector, focusing on power generation and transport and, to a lesser degree, industry. Even though electricity generation in Colombia is more than 70 percent hydropower, deep decarbonization requires large-scale changes in the sources of energy. The ideal future electricity generation mix cannot be foreseen with certainty today, but scenarios show the importance of the role of renewable resources; the role of hydrogen and second- and

third-generation biofuels; and the resulting implications for carbon capture, usage and storage (CCUS). Transport sector transformation will require increasing alternatives to road-based transportation (mass transit, rail, non-motorized mobility) and major electric vehicle uptake, including in the freight sector. Finally, achieving the targets will require a significantly greater effort in the AFOLU sector, drastically decreasing deforestation and increasing total land-based sequestration, turning Colombia's land from a carbon source into a carbon sink, and achieving emission reductions in agriculture. Owing to recent increases in emissions, the RNZP implies meeting a 2030 target even more ambitious than that of the NDC (maximum emissions of 150 MtCO₂eq vs. 169 MtCO₂eq) (Figure 3.6).³¹

FIGURE 3.6. To achieve its 2050 net-zero goal, Colombia will need to reduce emissions by at least 3 percent per year



Source: Historical emissions (2000–2018): Government of Colombia (2022); Modeled emissions (2020–2050): World Bank (2023e).
 Note: The modeled pathway uses government data, the latest of which are available for 2018. It is probable that 2021 emissions are higher than shown here, owing to deforestation levels that are 7 percent below target, and energy consumption that is 6.6 percent higher than 2018 (UPME 2020). As a result, the real RNZP would need to be steeper than shown here.

TABLE 3.2. Summary of transformations required by 2050

Sector	Milestones required by 2030	Transformation required by 2050	Emission reductions required by 2050, compared to 2018 emissions
Net FOLU	Annual deforestation no higher than 37,500 ha 25,000 ha reforested 620,000 ha afforested 5.8 million ha of land restored	An almost complete stop to deforestation, scale-up of agroforestry and silviculture systems, and forest plantations. Due to its large sequestration potential, the FOLU sector provides one of the few opportunities for creating “emissions space” for other sectors.	134 MtCO ₂ eq, equivalent to a 110 percent reduction
Agriculture	3.2 million ha of agricultural land sustainably intensified	There is a large increase in agricultural activities and land demand due to higher production of biomass for energy and food. This requires improvements in productivity, emission reduction technologies, and the reduced use of fertilizer.	9 MtCO ₂ eq, equivalent to a 79 percent reduction

³¹ In support of the government, the World Bank recently completed bottom-up modeling of a pathway for meeting Colombia's NDC's emission reductions target. The results of that exercise differ from the CCDR's top-down modeling effort in that achieving Colombia's 2050 net zero target will require even steeper emission reductions by 2030 than foreseen in the NDC.

Sector	Milestones required by 2030	Transformation required by 2050	Emission reductions required by 2050, compared to 2018 emissions
Livestock	16.3 million ha of livestock systems made sustainable Reduction in the expansion of pasture areas and livestock herd growth	Intensification of livestock production is key for freeing up areas that could be used for increasing crop production, with an emphasis on biomass. Moving from a current animal density of about 0.8 heads per ha to 2 heads per ha could free about 12 million ha for other uses (allowing for more than a doubling of currently planted areas). A reduction in meat consumption will eventually need to take place.	54 MtCO ₂ eq, equivalent to a 121 percent reduction
Transport	67% of public transport electric (0% in 2021) 20% of freight transported by rail (7% in 2021) 1750 km of bike lanes (1050 km in 2021)	A major emphasis on urban planning and public transportation, early planning of electrification of public transport systems, and the introduction of alternative fuels for long-haul, maritime, and airplanes. Usage of electric public transport systems doubles to serve more than 40 percent of total passenger mobility demand and walking and cycling represent 15 percent of trips.	31 MtCO ₂ eq, equivalent to a 81 percent reduction
Energy	24 GW of renewable electricity installed (15 GW in 2021) 42% of used in buildings to be derived from electricity (34% in 2021)	Increase the share of renewables in the primary energy mix and improve transmission grids using battery energy storage utilization and storage technology.	20 MtCO ₂ eq, equivalent to a 83 percent reduction
Industrial processes	2% of industrial energy from green hydrogen (0% in 2021)	Achieve the electrification of most industry, complemented by green hydrogen.	10 MtCO ₂ eq, equivalent to a 92 percent reduction

Source: World Bank (2023e).

3.5. Investment needs and economic costs of Colombia's RNZP

Colombia's RNZP will bring net economic benefits of US\$7 billion between 2023 and 2050, but will require an estimated additional investment of US\$92 billion (World Bank 2023e). The RNZP will result in a wide array of economic and social benefits estimated at US\$99 billion over 2023–2050 (in 2023 present value terms). These will include higher productivity in agriculture; operational, maintenance and fuel cost savings in the energy sector; and improvements in air pollution, road safety, and congestion in the transport sector. The overall pathway would require an additional investment of US\$92 billion, most of it during 2031–2050 (Table 3.3). This represents 1.2 percent of Colombia's discounted cumulative GDP over 2023–2050. The climate-related investment needs represent an incremental 18 percent above the baseline investment needs of US\$225 billion required in the energy, transport, AFOLU and waste sectors over 2023–2030, and 17 percent above the US\$326 billion required over 2030–2050.³² Total investments (US\$265 billion over 2023–2030, and US\$378 billion over 2030–2050) represent 10 percent of discounted cumulative GDP over 2023–2030 and 7 percent of discounted cumulative GDP over 2030–2050.

³² The baseline scenario assumes that investments required to meet economic development goals follow a minimum cost approach, with the model choosing the cheapest technology to meet that demand. The baseline scenario includes some investment in green technology (for example, solar panels, electric cars) because they become cheaper than other more polluting technologies. However, the baseline scenario assumes no new investment in non-road transport infrastructure.

TABLE 3.3. Additional investment needs and economic costs in the RNZP (in US\$ billion)

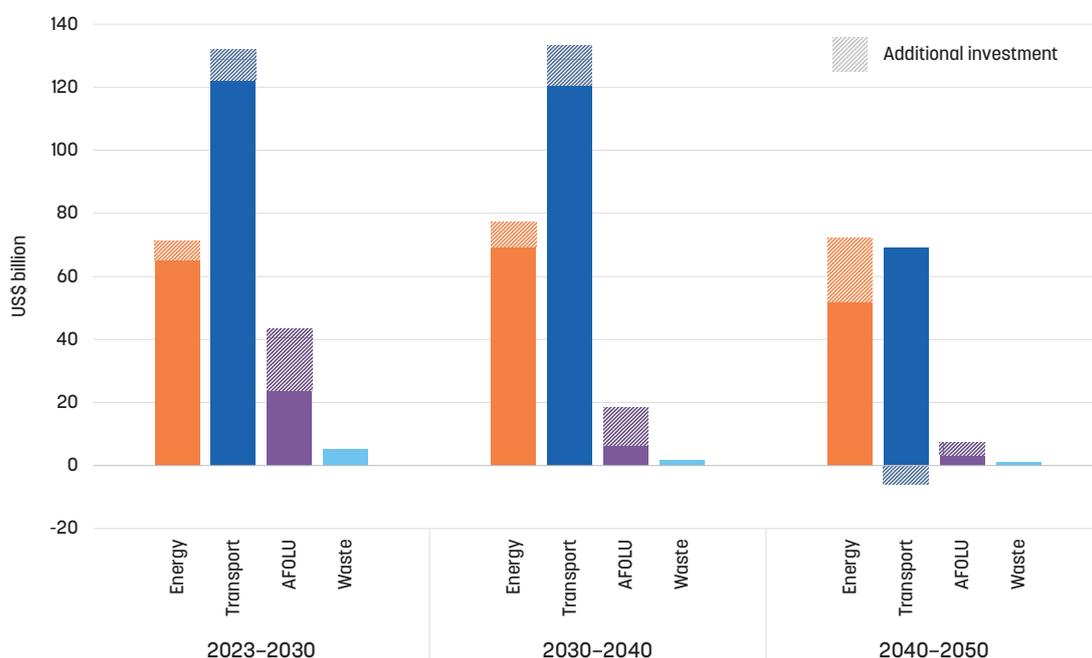
	2023–2030	2031–2050
ENERGY (excluding transport)		
Additional investment: electricity generation	1	4
Additional investment: transmission	3	9
Additional investment: H2 generation	0	9
Additional investment: efficiency and electrification of buildings and industry	<+1	1
Additional investment: resilient housing	<+1	0
Other economic costs: drought operational losses	-2	0
Other economic costs: operational, exports and imports	>-1	7
Other economic costs: air pollution externality costs	0	>-1
Other economist costs: housing disaster losses	0	>-1
TRANSPORT		
Additional investment: infrastructure (mass transit, freight and non-motorized)	11	20
Additional investment: resilient roads	<+1	0
Additional investment: fleet (trucks, cars and buses)	-1	-12
Other economist cost: energy and maintenance	-3	-11
Other economic costs: cost of disruptions	>-1	>-1
Other economic costs: air and noise pollution, congestion, and road fatalities	-1	-22
AGRICULTURE AND FOREST LANDSCAPES		
Additional investment: climate-smart agriculture, livestock, forestry, and conservation	19	17
Additional investment: resilient agriculture and wildfire protection	<+1	0
Other economic costs: productivity and ecosystem services	-2	-39
Other economic costs: operational and maintenance costs	-1	-18
Other economic costs: disaster losses	-1	-4
WASTE		
Additional investment: infrastructure	4	3
Other economic costs: energy and materials	>-1	-2
TOTAL INVESTMENTS AND ECONOMIC COSTS IN THESE SECTORS		
Net economic cost	30	-37
	Includes: additional investment	40
		52

Source: World Bank (2023e).

Note: All amounts are discounted using a 6 percent discount rate.

The transport sector requires the most overall investment to meet Colombia's RNZP, while the AFOLU and energy sectors require the most additional investment (Figure 3.7). Transport will absorb 52 percent of all investments needed over 2023–2050, driven by the need to convert the entire vehicle fleet to electric or green fuels and significantly expand public, rail, and fluvial transport. Due to Colombia's relatively clean electricity matrix, investment needs in energy make up a lower share of overall investments than in many other countries. However, AFOLU and energy require the most additional investment (38 and 36 percent above business-as-usual, respectively), given the significant effort needed for reforestation, afforestation, land management, and deforestation control, as well as the need to decarbonize costly-to-abate energy-sector activities, such as hydrogen production for industry or long-haul logistics. While transport and AFOLU investments need to be front-loaded in the first 15 years, energy investments are evenly distributed over 2023–2050 and are estimated to require the largest investment in the last decade as cheaper abatement options become exhausted and expensive technologies such as hydrogen become more feasible. In the transport sector, reduced motorization generates savings in the last decade.

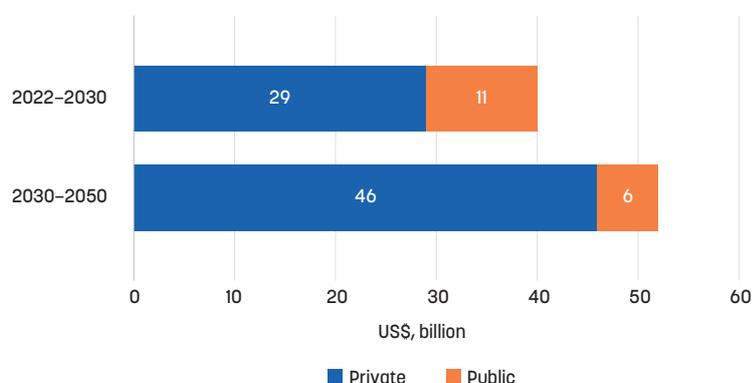
FIGURE 3.7. To meet Colombia's RNZP, the transport sector will require the most overall investment, and the AFOLU and energy sectors the most additional investment



Source: World Bank (2023e).
 Note: All amounts are discounted using a 6 percent discount rate.

It is estimated that about 80 percent of the additional investment will pertain to the private sector. Assuming that the respective private and public investment shares in each sector remain similar to the current shares, the additional private sector investment is estimated to be US\$29 billion over 2023–2030 and US\$46 billion over 2030–2050 (Figure 3.8). Additional private sector investment is estimated to be 95 percent of the total in the energy sector (power generation, the transmission and distribution systems, and efficiency updates), 56 percent in the transport sector (including infrastructure and fleet), and 93 percent in agriculture, forest and landscape (including crop intensification, commercial forestry, and land management). Public resources would be needed to subsidize new technologies in the energy sector (for example, battery storage, green hydrogen, pump cooling and heating systems) and for deforestation control and reforestation. All costs for waste management are estimated to be fully funded by the public sector.

FIGURE 3.8. Additional investment required to achieve a RNZP



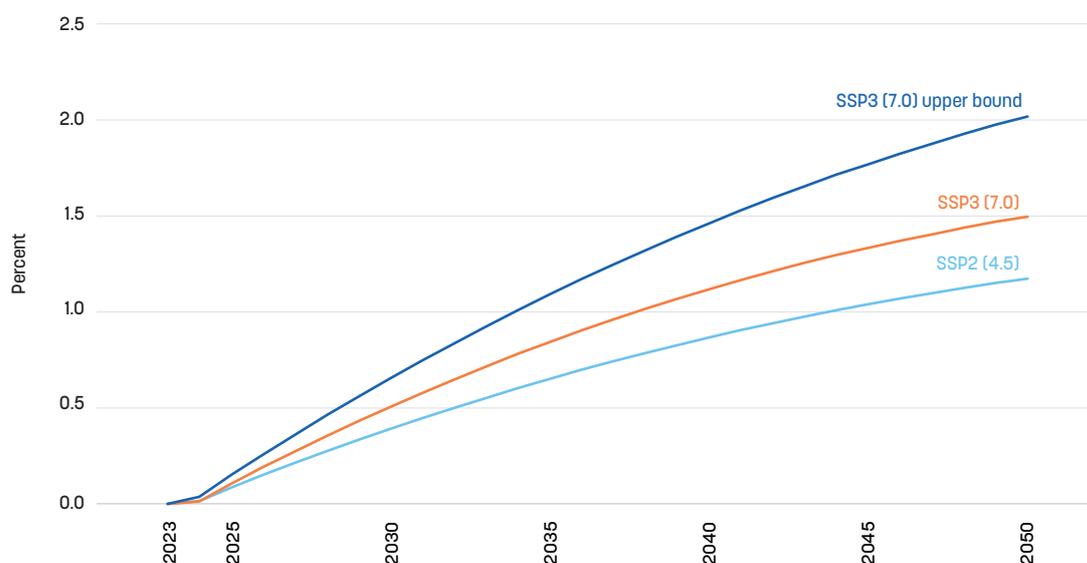
Source: World Bank (2023e).
 Note: All amounts are discounted using a 6 percent discount rate.

By reducing damage and losses from climate change, investment in adaptation is conservatively estimated to increase GDP by up to 2 percent relative a scenario without adaptation investment.

As illustrated in Section 1.2, once damage to physical capital and productivity are factored in, climate change is estimated to reduce GDP between 1.5 and 2.5 percent by 2050 and households' consumption by up to 3 percent, relative to a counterfactual scenario with no additional future change in climate. By 2050 adaptation investments could limit the reduction in GDP by as much as 1.2 percentage points under the most benign climate change scenario (the one with the least damage) and 2 percentage points under the most extreme scenario (the one with the greatest damage) (Figure 3.9).³³ In other words, adaptation investments could reduce the damage and losses from climate change by as much as 80 percent, but not entirely offset them.³⁴

This estimate shows that the direct benefits from climate investment are sizeable. It does not account for the economic effects of how this investment (especially the public share of it) is financed: Section 4 will analyze the general equilibrium effects of both climate investment and how this is financed. The estimate also suggests that more needs to be done to raise GDP, offset all the costs of climate change, and create the resources needed to achieve development objectives. Finally, by reducing damage, climate investment is estimated to increase household consumption relative to climate scenarios without such investment (Figure 3.10). The relative increase in consumption is estimated to be greater for rural than for urban households.

FIGURE 3.9. Investing in adaptation will reduce losses and increase GDP (deviation from scenarios with estimated climate change damage)

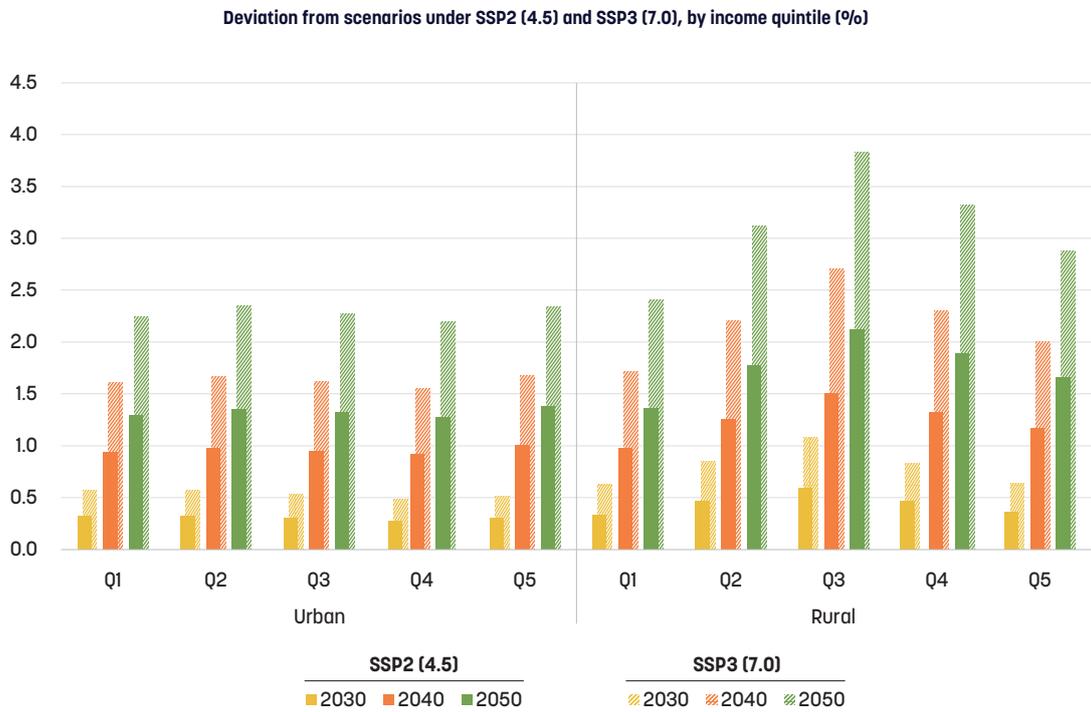


Source: World Bank staff estimates using MANAGE and based on data from DANE and Cardona et al (2021).

³³ To estimate the direct benefit of investment, the investment scenario in this subsection is compared to the damage scenario in subsection 1.2. Neither scenario accounts for the effects of global decarbonization. This is a simplifying assumption and corresponds to assuming that the effects of the global decarbonizations and the benefits of climate investment are independent of one another.

³⁴ In the simulations through the MANAGE model, we assume that climate investment will not entirely offset the faster depreciation of physical capital stemming from climate.

FIGURE 3.10. Estimated increase in household consumption resulting from investing in adaptation (by quintile of consumption distribution)



Source: World Bank staff estimates using MANAGE and based on data from DANE and Cardona et al (2021).

4. Macroeconomic implications of Colombia's climate transitions

Main messages

- Colombia will have to navigate its climate transitions and achieve its development objectives in a constrained macroeconomic environment, with little space to finance the additional investment required for adaptation, mitigation, and transition risks through increased external or government debt.
 - Meeting development and climate objectives will entail greater government spending. This in turn will require increasing tax receipts, including by increasing the carbon price.
 - In addition, measures to increase productivity and diversify exports will be needed, along with programs to mitigate the income effects of higher energy prices on the poor, as well as initiatives to reskill workers.
 - Finally, despite achievements to date, the green financial sector could be developed further to mobilize the resources needed for Colombia's climate transitions and development goals, by leveraging the green taxonomy, improving assessment and disclosure of climate-related financial risks, and developing climate finance instruments that meet the different risk and return profiles of potential investors.
-

Colombia must face three climate transitions, each with a macroeconomic impact: the transition from net positive to net zero emissions; the transition from a climate-vulnerable to a climate-resilient economy; and the transition to a world that will demand less of Colombia's main exports (oil and coal) and more green products. As indicated in the previous section, the first two of these transitions will require investment, reskilling of the labor force, adoption of new technologies, a change in the composition of taxes and spending priorities, and a change in the structure of private demand and of production. The transition away from extractive industries will compress what currently is an important source of foreign currency for Colombia's balance of payments and of revenue for its government accounts. It will also require policies to diversify the export base and improve the competitiveness and quality of Colombian products. Global decarbonization is a pressing risk for Colombia as it would constitute a structural shock to the country, with implications for the conduct of fiscal and development policies.

Climate change and the three resulting transitions do not alter Colombia's development objective and imperatives, and actions that advance development priorities will also support Colombia's climate transitions. For example, although the value of policies to increase productivity and diversify the economy is high regardless of climate change, this value is even higher when the consequences of climate change and decarbonization are factored in. In turn, the policies needed to navigate the climate transition and achieve national development objectives will impact growth, the sustainability of policies, and redistribution.

This section considers policy options for navigating the climate transition and improving development outcomes, and it presents estimates of the macroeconomic and distributional effects of these policy options. This is done mostly using the MANAGE model, the World Bank's recursive, dynamic, single-country, computable general equilibrium model designed to focus on energy, emissions, and climate change. Structural models like the Macro Fiscal Model (MFMod) and the partial equilibrium Carbon Pricing Assessment Tool are used to inform the calibration and simulations done with MANAGE. Before estimating policy effects, the section discusses the macroeconomic constraints within which the transition will take place.

4.1. Navigating the climate transitions and achieving development goals will require mobilizing significant resources in a constrained macroeconomic environment

The three climate transitions facing Colombia will generate financing needs at different levels for the Colombian economy. Specifically, the three transitions will variously:

- » **Require additional investment.** As mentioned in Section 3, the climate transition will need about US\$92 billion of additional gross investment (in net present value terms) between 2023 and 2050 relative to a baseline with no climate action. This is equivalent to about 23 percent of 2023 GDP or, on average, 1.5 percent of annual GDP of additional investment every year between 2023 and 2030, and 1.1 percent between 2031 and 2050. Since investment averaged 19 percent of GDP during 2017–2021, climate investment implies increasing the volume of investment by as much as 7.7 percent. Public investment is expected to have to increase by 0.4 percent of GDP every year between 2023 and 2030, and 0.2 between 2031 and 2050. For comparison, public investment averaged about 4.2 percent of GDP during 2018–2022.
- » **Reduce exports.** Oil and coal exports contribute about 34 percent of total inflows of foreign currency in the current account. Under its current export structure, the decarbonization of Colombia's trading partners would affect at least one-half of export receipts in the near and medium terms. Under a scenario in which other countries, especially advanced economies, meet their emissions targets, oil demand is projected to drop by 2030 to near its 2019 levels.³⁵ Because the United States and other advanced economies absorb about 40 percent of Colombia's oil, Colombia will likely face a sharp decline in demand for its oil starting in 2030, including because its average production cost is fairly high (about US\$45 per barrel).

Exports of coal will see a similar pattern. In the short term, the rising demand from emerging markets (the primary buyers of Colombian coal) and the current energy crisis in Europe will likely keep coal demand elevated; but the International Energy Agency (IEA) expects that Central and South America's coal production—92 percent of which comes from Colombia (BP 2021)—will fall between 45 percent and 61 percent up to 2030, and between 60 percent and 100 percent up to 2050 (IEA 2021b). In sum, under a global decarbonization scenario, Colombia is estimated to lose a cumulative US\$280 billion of export receipts between 2023 and 2050, or about 10 percent of the cumulative receipts from exports of goods and services relative to a scenario without global decarbonization.

- » **Reduce government revenues.** The extractive sector contributes about 3.5 percent of GDP to general government revenue. This is the equivalent of 14 percent of total general government revenues, and includes corporate income taxes, dividends of the national oil company, royalties, and other compensation from the sector. Using past elasticities of revenues to oil and coal exports, revenue losses from global decarbonization are estimated to average 1.2 percent of GDP between 2026 and 2030, and 1.6 percent of GDP per year between 2031 and 2050, or about 4.5 and 6.3 percent of total general government revenues respectively.
- » **Require increased spending to protect the most vulnerable.** The estimated annual cost of cushioning the impact on the poor, and on those falling into poverty because of a climate shock, is estimated at 0.1 percent of GDP (Dávalos et al. 2023).

Counting only additional investment for climate action, government revenue losses, and higher spending on adaptive social transfers, Colombia will need to mobilize on average 2.8 percent of GDP of additional resources, between 2030 and 2050, relative to a (costly) scenario without climate actions. This is equivalent to about US\$ 14 billion per year (at current prices), through 2050. Colombia's public sector will have to mobilize at least 1.7 percent of GDP between 2023 and 2030 and up to 1.9 percent of GDP afterward, summing up revenue losses from global decarbonization, additional investment needs, and adaptive transfer programs. The private sector would need to mobilize the remaining 1.1 and 0.9 percent of GDP respectively.

³⁵ Even under current global policies, the decarbonization of trading partners is projected to lead to a steady decline in global fossil fuel demand starting in the mid-2020s (IEA 2021a).

The current macroeconomic environment limits how the economy can absorb the costs of the transition and the range of policies needed to allow this. Since 2000, Colombia has been enjoying a stable macro framework, characterized by both internal and external balance (stable growth, low inflation, and an overall moderate current account deficit) and supported by a strong macroeconomic policy framework (inflation targeting, flexible exchange rate, and rule-based fiscal policy). In 2020 the fiscal response to the COVID-19 crisis pushed the general government deficit to 7 percent of GDP, and the debt-to-GDP ratio to over 66 percent. While the recovery of activity, tax reforms, and the phasing out of emergency spending facilitated a reduction of the deficit and the debt-to-GDP ratio during 2021 and 2022, imbalances started to emerge: The economy overheated, with activity running above the estimated potential, double-digit inflation, and an increasing current account deficit despite positive terms-of-trade shocks. This has happened within a context of a high debt-to-GDP ratio and high fiscal deficit.

These developments affect the policy space for navigating the climate transition and achieving development goals over the short and long runs, along three dimensions: the external position and national savings, public finances, and the growth model.

4.1.1. The constraints posed by the external position and national savings

The loss of fossil fuel exports can be sustained only if imports fall or Colombia starts exporting more other products. Colombia's external net liabilities are currently 56 percent of GDP, one of the largest ratios among Latin American and the Caribbean countries. Although the composition of assets and liabilities makes Colombia's external position less of a concern than the headline number suggests, in 2022 the current account deficit reached 6 percent of GDP, about 3–3.5 percentage points greater than what is estimated will prevent net liabilities from growing as a share of GDP. Absorbing the loss of oil and coal exports while keeping the current account deficit at or below 2.5–3 percent of GDP will require either reducing imports and/or expanding other exports. Reducing imports without expanding exports would require both a fall in domestic demand and a depreciation of the currency, favoring import substitution. However, given that over one-third of Colombia's government debt is denominated in foreign currency, a more depreciated currency would require additional efforts to keep public debt sustainable. To absorb the effects of global decarbonization, Colombia cannot fail to increase exports of other products.

With little export sophistication and diversification, increasing exports will not occur in the absence of reforms. Colombia ranks as one of the countries with the highest export product concentration among its peer countries (Signoret and Tovar 2021). Also, it does not have comparative advantage in exporting sophisticated goods with rising demand in the climate transition: it ranks 74th out of 122 countries in the IMF's Green Complexity Index (IMF 2022), well below Mexico (22nd) and Brazil (46th).

So far, Colombia has not been able to leverage the potential of exporting “climate minerals” to meet rising demand. Colombia extracts gold, ferrous metals, and copper and has deposits of silver, zinc, cobalt, manganese, and coltan (SGC 2020). However, the currently proven stock of copper is nearing its end (DANE 2022a), it is estimated that iron reserves will last 15 years at current extraction rates, the amount of gold reserves is not fully known, and other “climate minerals”³⁶ barely account for 2.8 percent of total exports. While nickel has potential, even assuming that the current stock of ferronickel is exploited over the next 30 years, their export value would account for the equivalent of only 15 percent of current oil and coal exports.

Leveraging agriculture to diversify exports will require more actions than just those aimed at strengthening the resilience of the sector in the face of climate change. The projected 0.6 percent annual growth of global demand for agriculture and livestock products is an opportunity for Colombia to expand its share of global agriculture markets. However, the agricultural products that make up the largest share of Colombia's non-extractive exports are vulnerable to the intensification of climate events: Coffee and fruit account for at least 31 percent of agricultural exports and are sensitive to increases in precipitation. Others,

³⁶ Climate minerals are metals and minerals for which demand is expected to increase because of global decarbonization, such as aluminum, nickel, and cobalt.

such as bananas, plantains, and oil palm (which account for about 18 percent of agricultural exports) are more resistant to precipitation and temperature changes but are mainly grown in littoral departments where they are exposed to flooding, and, over the longer term, sea-level rise (Ramirez-Villegas et al. 2012). Hence, it is important that Colombia adopt the policies proposed in Section 3.1.2 to strengthen the resilience of its agricultural sector amid climate change and expand exports of agricultural products. So far, Colombia has leveraged its comparative advantage in the production of bananas and coffee, which are consumed in high amounts at the global level. However, the country has insignificant market share in some products for which its productivity is high and that are in high demand at the global level, such as apples, pineapple, mangoes, or rice.

There are opportunities to move the composition of exports toward higher value-added goods. Currently, Colombia has a relative disadvantage in exports of environmental goods (IMF 2022): Environmental goods contribute only 2.1 percent to non-mining exports, or 1.1 percent of total exports (Banco de la República 2023; IMF 2022). Nevertheless, Colombia has the potential to strengthen its participation in markets of green-related electrical and mechanical machinery parts, inorganic chemicals, and cleaning supplies. For instance, exports of lead-acid electric accumulators, which contribute the most to Colombia's environmental goods trade, grew 16 percent between 2017 and 2021. Other products with solid growth rates—around 2 percent annually on average in the last few years—include undenatured ethyl alcohol, machines and mechanical appliances for asphalt pavers, manganese dioxide, phosphates of calcium, mechanical floor sweepers, and taps, cocks, and valves. However, the export of environmental goods would have to increase at an annual rate of about 11 percent between 2023 and 2030 to make up for half of the lost oil and coal export receipts.

Improvements in technology adoption and adaptation, a revision of tariff- and non-tariff barriers, and a better logistics environment could help increase exports. Colombia's Internationalization Mission (DNP 2021) identifies enhancing innovation (including by increasing the presence of foreign companies and facilitating the mobility of human capital) and reducing transaction and logistic costs as enablers for a higher level of (and a more sophisticated) integration into world trade. In particular, streamlining non-tariff barriers, reducing tariff dispersion and peaks, strengthening the implementation of the National Logistics Policy, and enhancing competition in the domestic market are identified as key to expanding non-mining exports. Also, increasing proficiency in programming, software, and language skills, adapting the business environment for modern services, and prioritizing foreign direct investment (FDI) flows to the service sector would increase trade in services.

In broad macroeconomic terms, higher investments will require an increase in national savings. An increase in investment can be accommodated either with an increase in national savings, an increase in the current account deficit, or a combination of the two. After peaking at 20 percent of GDP in 2008, national savings have stabilized at about 16 percent of GDP since 2018 (excluding 2020 and 2021 when savings dropped). After 2013, the decline of public savings is estimated to have accounted for the entire decline in national savings, while private savings have been on an increasing trend since 2013. If Colombia is to reduce its current account deficit to 2.5–3 percent of GDP over the medium term, and then keep it at that level over the long run (to prevent net external liabilities from growing indefinitely), the higher investment necessary to finance the climate transition will require national savings to increase to about 20–21 percent of GDP, at least until 2030. A decline in the (current) fiscal deficit would help increase public savings, while higher interest rates and a deepening of financial sector would help increase private savings.

4.1.2. The constraints posed by the fiscal position

The government has no space to increase net borrow by between 1.7 and 1.9 percent of annual GDP to absorb revenue losses and higher climate-related spending. Before the COVID-19 crisis, the general government deficit hovered around 2.5 percent of GDP. The fiscal response to COVID-19 in 2020 pushed the general government deficit to 7 percent of GDP and the debt-to-GDP ratio to over 66 percent. While the recovery of economic activity, tax reforms, and the phasing out of emergency spending is facilitating a reduction of the deficit and the debt-to-GDP ratio, bringing that ratio down to the government's target

of 55 percent of GDP will require keeping the deficit between 2 and 3 percent of GDP over the long run, similar to pre-COVID levels.³⁷ In addition to keeping the debt-to-GDP ratio sustainable, a lower deficit would increase national savings.

Although spending efficiency can be improved, there is little space to cut the level of public spending to absorb the revenue losses and climate-related spending. Until 2019, general government spending, excluding interest payments on debt, amounted to 29 percent of GDP. There is little space—in particular at the central government level—for cutting current spending because Colombia would need to expand the level and quality of public education, health, and other public services to meet its development goals and also need to strengthen the social security system, irrespective of climate change. Colombia could improve spending efficiency and reduce waste in inefficiently distributed utility subsidies, which would open fiscal space between 0.3 and 0.4 percent of GDP (World Bank 2021e).

The foregoing implies that Colombia will need higher and better taxes to navigate its climate transition and achieve its development goals. Colombia raises fewer taxes than other emerging-market countries—19 percent of GDP against 22 percent on average in LAC, and 34 percent in the OECD (OECD 2023)—and relies on a different composition of taxes than most other peer and aspirational countries: Colombia taxes corporate income more and personal income and property less than other countries do (World Bank 2021e). It also gives up on a large amount of revenue (about 4 percent of GDP) in inefficient and poorly targeted tax exclusions and deductions on corporate income and the value-added tax. Even absent the climate transition, Colombia would have had to raise taxes to finance the attainment of its development objectives.

Although Colombia was a global leader in introducing a carbon tax in 2016, the country raises significantly less revenue than its peers from carbon, fuel, and energy taxes. Because of its scope, level, and offsetting provision, Colombia's carbon tax has had a limited effect on both emission reductions and revenue collection: on average, the tax has raised 0.03 percent of GDP annually since its inception (MHCP 2022) while directly reducing emissions by 0.31–0.35 MtCO₂e per year between 2017 and 2019, or about 1/1000th of Colombia's current annual GHG emissions.³⁸ The tax rate, at COP 20,500 (US\$4.44), is well below the social cost of carbon,³⁹ and its current design would not reach the levels recommended for 2030. While the carbon tax level is broadly similar to regional comparator countries, Colombia's effective carbon price, composed of the explicit carbon tax and excise taxes on fossil fuels—excise taxes in Colombia price carbon more than seven times as much as the carbon tax—is US\$7.3/tCO₂e. This is representative of Colombia's low overall share of environmental taxation: 0.6 percent of GDP versus an average of 1.1 percent in LAC, and 1.4 percent in the OECD (OECD 2021b).

In addition to raising fewer revenues from fossil fuel-based GHG emissions than peers, in 2022 Colombia spent about 2.6 percent of GDP on fuel subsidies (MHCP 2022), with the result that its net effective carbon rate is low in comparison to peers. In 2007, the government established a formula and a financing mechanism (the *Fondo de Estabilización del Precio de los Combustibles*) that, in principle, allow smoothing the pass-through of large fluctuations of international fuel prices on the domestic market, without incurring fiscal costs over price cycles. However, since its inception, domestic prices have been below international prices, and the system effectively established fuel subsidies equivalent to about 50 percent of the international price. Not only do these subsidies generate large fiscal costs (estimated at 2.6 percent of GDP in 2022), but they also counteract 75 percent of the demand effect of the carbon tax, reducing its effective carbon rate by 9 percent to US\$6.7/tCO₂e,⁴⁰ significantly lower than its peers (Figure 4.1). The government has established a path for decreasing fuel subsidies to almost zero, but a permanent solution to eliminate these subsidies over the long run is still outstanding.

³⁷ Higher growth could allow keeping the debt-to-GDP ratio stable with a higher deficit, but the growth rate would need to be more than 7 percent per year to keep debt at 55 percent of GDP with a deficit of 5.2 percent of GDP.

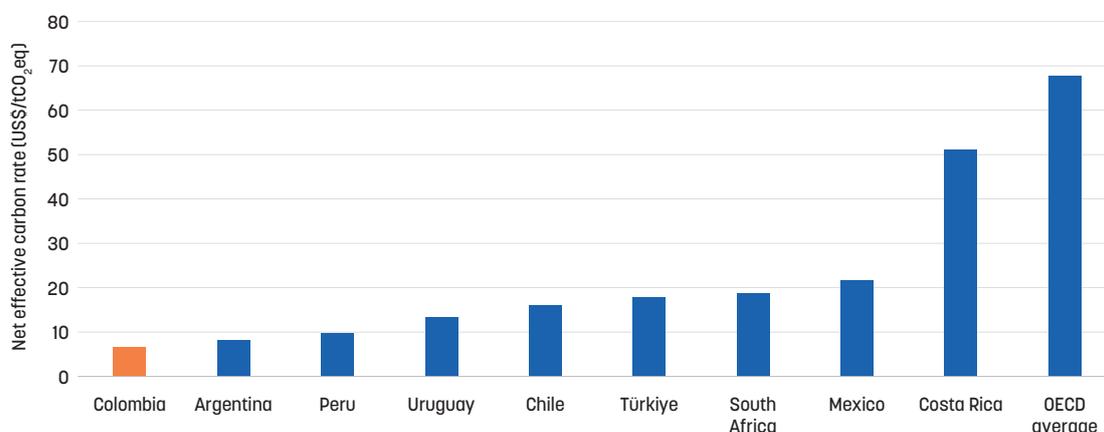
³⁸ The tax's offsetting mechanism has generated additional emission reductions; however, evaluating their effectiveness would require in-depth research.

³⁹ Recommendations for the social cost of carbon vary between US\$26/tCO₂e (Alatorre et al. 2019) and US\$40–80/tCO₂e (CPLC 2017). The social cost of carbon represents the optimal value of a carbon price that factors in the externalities of GHG emissions.

⁴⁰ World Bank calculation based on 2021 data from OECD (2021a). Following the 2022 reform of the carbon tax, these numbers would change slightly, although the order of magnitude and direction of the effect would remain the same.

The 2022 reform of the carbon tax and the upcoming introduction of Colombia's emissions trading system should improve the scope and coverage of carbon pricing in Colombia, but on balance, the country still has room to expand its carbon pricing regime.

FIGURE 4.1. Colombia prices carbon emissions significantly lower than its peers (net effective carbon rate, US\$/tCO₂e)



Source: OECD (2021).
Note: All values are for 2021.

4.1.3. The constraints posed by the current growth model and structural challenges

Absorbing the investment needed for the climate transition requires not only softening the constraints posed by the external and the fiscal positions, but also creating an environment that enables both the public and the private sectors to embark on the transformational changes that the climate transitions require. Three features of the Colombian economy are central to Colombia's ability to adopt greener technologies, invest in climate action, diversify exports to offset export losses from global decarbonization, and raise revenues to fund public climate investment. They are:

- » **Low productivity:** Since the mid-1950s, Colombia's economy has grown mostly by accumulating factors of production, and little by increasing total factor productivity. In other words, more physical capital and labor have been put to work, but little improvement has occurred in *how* these factors do their work. Explanations include the presence of a large share of micro and small enterprises with low productivity—90 percent of Colombian firms are microenterprises—weak managerial capacity in larger firms, low preparation of the labor force, and the high monetary and non-monetary costs of compliance with rules and regulations. In addition to low growth, this model has led to a decrease in natural wealth, as discussed in Section 3.1.1.
- » **Low public investment rate and low exports:** Compared to other countries, Colombia has grown little through investment and exports. While private investment is comparable to that of other countries, public investment lags behind. In addition to making sure that Colombia has the macroeconomic space to accommodate additional climate investment, it is important to ensure that it also has the capacity to absorb such investment. Currently, Colombia is effectively closed to trade,⁴¹ and the country has high non-tariff barriers (DNP 2021). Yet Colombia will likely need to step up imports of products, technology, and services for its climate transition.

⁴¹ The sum of exports and imports, a standard measure of trade openness, is only 37 percent of GDP, putting Colombia in the lowest 15 percent of trade openness among countries with more than 30 million inhabitants (World Bank 2022e).

- » **The high level of informality:** Informality permeates Colombia's productive sectors,⁴² representing an additional structural constraint on development and on the climate transitions. Informality, among other consequences, leads to poor access to credit and technology, and to low investment and innovation. At the same time, by moving activity and income outside the tax net, informality reduces the government's tax base.

Responding to climate change will require adopting technology and innovation, expanding exports, and lowering informality. For example, increasing renewable energy production will require not only capital goods (such as wind turbines and solar panels) but also consumption goods (like electric cars, batteries, and thermally efficient windows). Making these goods available and adopting the technology needed to operate them will likely require greater trade opening. Finally, mobilizing the resources needed for the transition and increasing overall productivity would have to be accompanied by measures that favor formalization.

4.2. Colombia's climate transition and development aspirations require policies to boost productivity and exports, increase revenues, and shield the poor from transition costs

Colombia's solid macroeconomic policy framework, anchored by inflation targeting, exchange rate flexibility, and a fiscal rule, will help it to achieve its development objectives and the climate transition. The climate transition will likely impact the relative prices of goods and services, aggregate demand and supply, and growth. Inflation targeting will help manage the economic effects of relative prices changes, demand and supply shocks, and structural shifts in the economy that impact the neutral interest rate. A flexible exchange rate regime will help the economy adjust to changes in terms of trade and to structural shifts in the level of exports. Finally, the fiscal rule, with its explicit long-term target for the debt-to-GDP ratio, will help maintain fiscal sustainability and guide changes to the level of taxes and current spending that are needed to compensate for lower oil and coal revenues and higher public investment.

The macroeconomic policy framework will determine how macro variables will adjust during the transition. The simulations of the macroeconomic effects of climate action and policies assume that the exchange rate will move so as to keep the current account at around 2.5–3 percent of GDP over the long run, which is the level needed to stabilize Colombia's net international investment position. Depending on the effectiveness of policies to diversify and increase exports other than oil and coal, it is assumed that the exchange rate will depreciate more (or less), forcing a large (or small) contraction of imports and making exports more price competitive. It is also assumed that the fiscal deficit will adjust to keep the debt-to-GDP ratio stable at around 55 percent of GDP. This means that, under different scenarios, the contraction in spending and/or increase in revenues (hence, the impact of fiscal policies on GDP) will also depend on the debt-to-GDP ratio. Under these assumptions, both MFMod and MANAGE project that under a transition scenario with climate change and global decarbonization but no policy adjustments, GDP growth could reach about 3 percent.

4.2.1. Increasing the effective carbon price and increasing overall taxes would allow financing public climate investment, make up for lost oil and coal revenues, and protect the poor from higher fuel prices

Colombia has room to increase its effective carbon price. Under the current carbon tax design, carbon taxes would reach US\$21/tCO₂e by 2030, which is not ambitious enough to lead to a significant reduction of GHG emissions. The carbon tax therefore does not significantly contribute to the achievement of Colombia's NDC, placing a greater burden on sector-specific actions that are likely to be costlier to the economy. Also, it would not be enough to finance additional public climate investment: Carbon tax revenue is projected to reach about 0.03 percent of GDP in 2025 and 0.1 percent of GDP by 2030. The planned introduction of an emissions trading system will increase the scope, but not necessarily the level, of Colombia's carbon price.

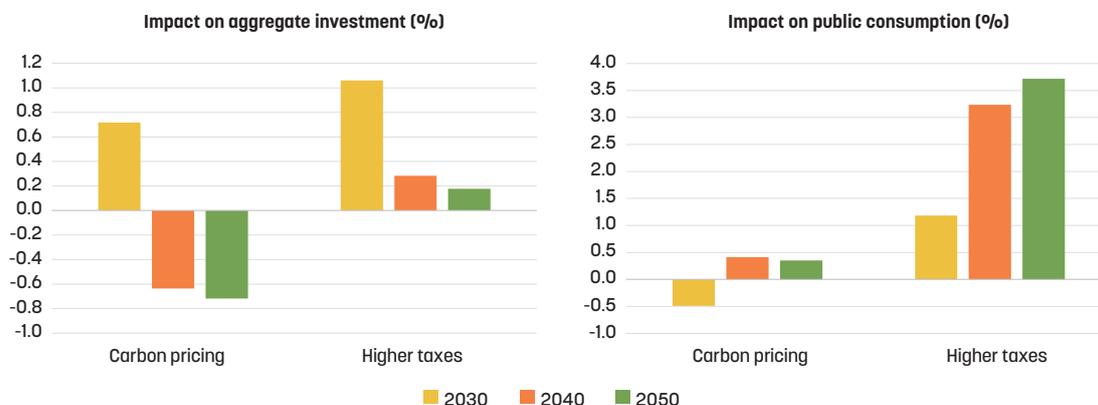
⁴²About 60 percent of workers and over 80 percent of firms are informal (DANE 2022c).

A higher effective carbon price can be achieved in one of two ways and would incentivize emission reductions while mobilizing public financing. The options are to increase the carbon tax and/or increase excise taxes. Under the current carbon tax design, total emissions are estimated to fall by 2.6 percent from the NDC's baseline scenario by 2030, but up to 40 percent if the carbon tax reached US\$67/tCO₂e by 2030 (consistent with a slow decarbonization scenario of net zero by 2060 (OECD 2021)). Emissions are estimated to fall across all sectors, but the largest reductions would be observed in industry. A carbon tax increase would reduce fuel consumption by increasing prices. For example, with higher carbon taxes, the price of gasoline is estimated to increase 15 percent and the price of diesel 18 percent relative to the current carbon tax. Finally, revenues are estimated to increase up to 0.7 percent of GDP per annum (about US\$4 billion) by 2030, using a partial equilibrium model (Carbon Pricing Assessment Tool) (World Bank and DNP 2023).

Although increasing effective carbon prices would be enough to finance public climate investment, it would not be enough to also offset revenue losses from global decarbonization and would have a negative impact on GDP and household consumption. By increasing energy prices, the carbon price increase would lower investment and consumption, including compared to a scenario where public climate investment is financed by cutting other spending and raising other taxes, or compared to a scenario (unsustainable) where public climate investment is financed through debt. Yet relative to a scenario with climate change but without public climate investment, GDP would still rise. In addition, because the carbon price increases energy prices, households' purchasing power and consumption would on average fall 0.8 percent by 2040 across all income groups, with the largest consumption loss—up to 0.9 percent—incurred by the poorest households (Table 4.1).

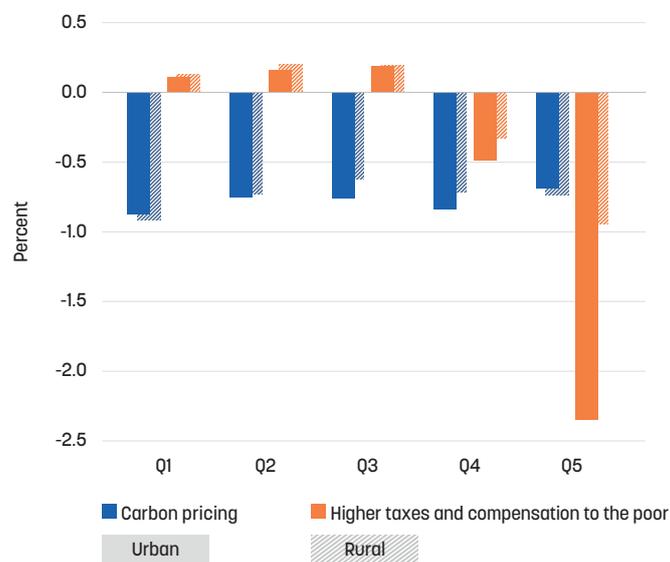
In addition to increasing carbon prices, Colombia would also need to increase total taxes, preferably in a way that raises the progressivity of the tax system and minimizes impact on growth (Figure 4.3). The World Bank (2021e) proposes concrete measures to increase taxes by between 0.3 and 0.7 percent of GDP while shifting the composition of taxes in a way that raises the progressivity of the tax system and is supportive of growth. These measures, and a higher effective carbon price (as suggested above), would generate enough funds to (i) pay for public climate investment, (ii) compensate households in the first three deciles of the income distribution for real disposable income losses caused by carbon pricing, and (iii) offset part of the revenue losses from the global decarbonization. Compensating poor households would cost slightly less than 0.1 percent of GDP, or only about 14 percent of revenue from carbon pricing. If designed appropriately (see World Bank (2021e)), these additional tax increases would have a minimal impact on GDP (relative to only using carbon pricing) but would lead to higher investment and higher public spending (Figure 4.2). Also, if revenues (other than those from carbon pricing) are increased through progressive taxes, the entire policy package would be progressive, with household consumption increasing 0.6 percent for the poorest income groups, while the richer income groups would bear the bulk of the cost with a decrease in consumption of up to 2.5 percent.

FIGURE 4.2. With the right composition, increasing other taxes supports investment and allows increasing public spending (percentage change in total investment and public consumption under carbon pricing only and carbon pricing plus other taxes, relative to a scenario without climate action)



Source: World Bank staff estimates using MANAGE and based on data from DANE.

FIGURE 4.3. Increasing other taxes can create space to compensate the most vulnerable households for losses from higher carbon prices (percentage change in household consumption, by quintile, relative to a scenario without comprehensive tax reforms)



Source: World Bank staff estimates using MANAGE and based on data from DANE.

TABLE 4.1. Assumptions underlying scenarios and comparison across scenarios

	Scenarios ¹						
	No climate change	Climate damage	Global decarb.	Climate invest.	Carbon pricing	Carbon pricing and higher taxes	Higher productivity
	(0)	(A)	(B)	(C)	(D)	(E)	(F)
Damage and losses							
Damage under SSP2 (4.5)		x	x	x	x	x	x
Damage under SSP3 (7.0)		x		x			
Damage SSP3 (7.0) upper bound ²		x		x			
Global decarbonization			x		x	x	x
Climate investment							
				x	x	x	x
Funding for climate investment							
Carbon tax					x	x	x
Increase in other taxes						x	x
Compensation for the poor						x	x
Higher productivity							x
Level differences at 2050 (percent)							
		(A) - (0)	(B) - (0)	(C) - (A)	(D) - (B)	(E) - (B)	(F) - (B)
GDP (under SSP2 (4.5))		-1.5	-9.7	1.2	0.2	0.3	up to 16
GDP (under SSP3 (7.0) upper bound) ²		-2.5	n.a.	2.0	n.a.	n.a.	n.a.
Total investment		0.0	n.a.	0.0	-0.7	0.2	
Government consumption		0.0	n.a.	0.0	0.4	3.7	
References:		Fig. 1.5, 1.6, and 1.7	Sect. 1.2	Fig. 3.9 and 3.10	Fig. 4.2 and 4.3	Fig. 4.2 and 4.3	Fig. 4.4

Source: Authors' estimates.

¹ Although there are non-linearities in the model, summing differences across scenarios offers a good approximation (that is, as an example, the GDP difference between scenario (D) and (0) is approximately equal to (D) - (B) + (B) - (0)).

² Upper bound = SSP3 (7.0) scenario.

4.2.2. Increasing labor productivity will be needed to create additional macroeconomic space to finance the climate transition

In addition to policies to diversify exports or increase revenues, increasing growth will be important for creating space to relax the macroeconomic constraints. Growth would open up space to finance and absorb greater investment, and to reduce vulnerabilities to a wider range of shocks than those strictly related to climate. For example, higher growth would allow running higher fiscal deficits while keeping the debt-to-GDP ratio stable.

Increases in labor productivity in different sectors have different impacts on GDP. Figure 4.4 shows the estimated additional impact on the level of GDP (relative to the scenario of the previous section) of three alternative scenarios of productivity increases: a permanent 2 percent annual increase in labor productivity (i) in the agricultural sector, (ii) in the manufacturing sector, and (iii) in both sectors.⁴³ Productivity growth in a sector increases its competitiveness and leads to higher output and demand for factor inputs, higher wages, and higher demand for intermediate and final inputs, which have positive spillover effects in other sectors and on GDP. Owing to its smaller size in the economy, increasing productivity of only the agricultural sector—for example, by repurposing agricultural subsidies toward green innovation (see Section 3.1.2)—increases GDP in 2050 by less (6.2 percent) than increasing productivity in manufacturing (9.9 percent). These differences in the *level* of GDP are equivalent to an increase in real GDP *growth* from 3 to 3.2 and 3.4 percent, respectively. Of course, increasing productivity in both agriculture and manufacturing would have an even greater impact on GDP (in level)—on the order of 16 percent, equivalent to 3.6 percent growth.

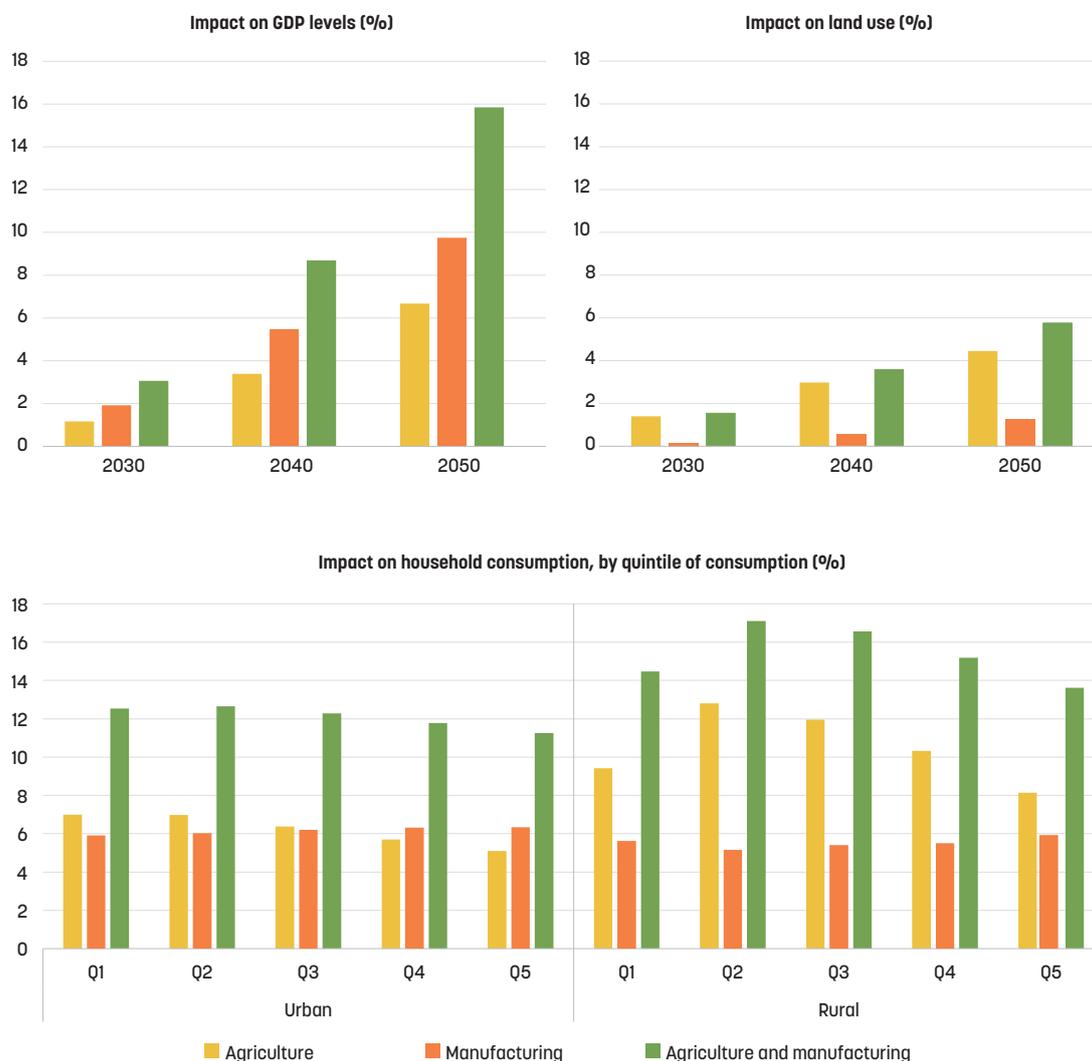
Yet there could be tradeoffs in terms of land use. While higher productivity in agriculture is important to help meet a growing demand for food and boosting rural incomes in the transition, it could create pressure on forests in the absence of the kinds of deforestation control policies outlined in 3.1.1 or in the absence of effective policies steering agricultural development away from areas of high deforestation risk. Higher productivity in manufacturing also results in higher demand for land (because as aggregate demand rises, so does demand for agricultural products). However, because the spillovers generate a lower increase in agricultural production, the pressure on forests increases less (Figure 4.4).

Increases in labor productivity in different sectors also have different impacts on household consumption. Productivity increases in the agricultural sector raise rural households' consumption more than urban households', thereby somewhat closing the consumption gap between rural and urban households. Increases are also greater for poorer rural households. Consumption increases from higher-productivity growth in manufacturing are similar across income groups and across urban and rural households (Figure 4.4).

An additional benefit of increased productivity is that it eases fiscal constraints and supports export diversification. Indeed, a rise of 0.4 percentage points in growth would allow expanding the fiscal deficit by 0.3–0.4 percent of GDP while keeping the debt-to-GDP ratio stable at 55 percent of GDP. That is, the government could increase its annual net borrowing by up to 0.4 percent of GDP without affecting debt sustainability. Improvements in manufacturing productivity would have positive effects on the competitiveness of the Colombian economy and would create an environment favorable to export diversification.

⁴³ Qualitatively, the results do not change if total factor productivity is increased instead of labor productivity.

FIGURE 4.4. Increasing productivity in manufacturing raises GDP and household consumption, but also leads to lower increases in land use relative to increased agricultural productivity



Source: World Bank staff estimates using MANAGE and based on data from DANE.

4.2.3. Macroeconomic policy for climate action and development

Supporting climate action and achieving development goals will require coordinated and transformational measures across multiple dimensions. Specifically, Colombia would need to:

- » Raise the effective carbon price, extend its coverage, and increase other taxes while promoting progressivity and limiting the impact on economic activity (World Bank 2021e). At the same time, it would be important to improve spending efficiency to open up fiscal space.
- » Offset the impact of higher effective carbon prices on the poor. This can be done by compensatory payments to the poorest households (at least those in the bottom two deciles of the income distribution) for the direct and indirect effects of higher carbon prices.

- » Quickly eliminate fuel subsidies. The government has indicated that fuel subsidies will be significantly reduced (or even eliminated) over the medium term. Not only would eliminating fuel subsidies open up fiscal space; it would also augment the effects of carbon pricing on emissions.
- » Increase the productivity of labor and of the economy in general, manufacturing in particular. This can be done by reducing barriers to entry for firms, reducing the costs of complying with rules and regulations, reducing barriers to accessing credit, and expanding digitization.
- » Favor export diversification and increase the export participation of products with high value-added. Actions include attracting foreign direct investment in non-traditional sectors, leveraging international migration to Colombia and Colombian migration abroad to increase the transfer of knowledge, and improving commerce, logistics, and institutions for trade.

4.3. Financing the resilient net-zero pathway

Mobilizing financing is critical for Colombia to navigate the climate transition and to achieve its development goals. Between 2011 and 2021, Colombia mobilized about 24.3 trillion pesos for climate adaptation and mitigation from public, private, and external sources (DNP and Fedesarrollo 2022). On average, this was the equivalent of 0.2 percent of GDP. Of this total, 4.5 trillion pesos in grants were provided by external sources. The investments required for Colombia to meet its climate objectives will require a significant scale-up of financing well beyond these figures.

This requires action on two fronts. First, identifying sources of financing. This includes repurposing carbon-intensive subsidies and direct public financing of climate-smart investments, but also tapping global, bilateral, and multilateral sources of finance and climate financing initiatives. Second, making sure that financial regulations are designed to equip financial institutions to identify sources of financing and mobilize them for the best uses. On both fronts, the actions will involve the public and private sectors, including the financial sector.

4.3.1. The estimated additional financing needs

Additional financing needs from the private and public sectors will amount to about 1.5 percent of GDP between 2023 and 2030, and 1.1 percent of GDP between 2031 and 2050. This would constitute a level of climate financing 5–7 times what has been mobilized so far. These numbers assume the following, which is summarized in Table 4.2:

- » **The government will be able to fund part of the climate transition by raising revenue and improving spending efficiency but would need to increase net borrowing and/or mobilize donor resources by about 0.4 percent of GDP between 2023 and 2030, and 0.2 percent of GDP between 2031 and 2050.** As discussed in Section 4.1, the government would need to mobilize between 1.6 and 1.8 percent of GDP to make up for revenue losses from global decarbonization and additional spending related to the climate transition. The increases in the effective carbon price and increase in other taxes could contribute between 1 and 1.4 percent of GDP. As indicated in Section 4.1.2, spending efficiency measures, especially on utility subsidies, could free up 0.4 percent of GDP. Greater growth from increased productivity could allow covering residual financing up to 0.4 percent of GDP per year. This is because greater growth would allow the government to expand the deficit without affecting debt sustainability.
- » **The private sector would need to finance additional climate investment up-front and would only later recover the costs through increases in prices or reduced operational costs.** Under this assumption the private sector additional financing need would amount to about 1.1 percent of GDP between 2023 and 2030, and 0.9 percent of GDP between 2031 and 2050.

Estimates of additional demand for climate finance might be different from estimates of additional financing needs. Climate finance is one of many financing sources. In the case of the government, demand for climate finance will likely depend not only on the amount of climate investment but also on how green borrowing fits the overall financing strategy. For example, if green bonds allow the government to lower financing costs, extend maturity, or reduce exchange rate risks, government issuance of these instruments might as well be as high as total green investment, even if revenues have gone up (or, alternatively, other spending has come down) as suggested above.

TABLE 4.2. An illustrative pathway for funding Colombia's climate transition costs

Range of additional financing needs (in percent of GDP)		
	2023–2030	2031–2050
Total: public + private	1.5	1.1
<i>Public sector (= A - B)</i>	0.4	0.2
<i>(A) Climate transition costs</i>	1.7	1.9
Revenue losses from oil and coal	1.2	1.6
Additional climate investment	0.4	0.2
Adaptative social security	0.1	0.1
<i>(B) Resources from revenue shifts and spending reductions (net)</i>	1.3	1.7
Carbon pricing	0.7	0.7
Higher taxes	0.3	0.7
Increase efficiency of spending and subsidies	0.4	0.4
Compensation for the poor	-0.1	-0.1
<i>Private sector (= C)</i>	1.1	0.9
<i>(C) Additional climate investment</i>	1.1	0.9

Source: Authors' estimates.

4.3.2. Development of climate finance instruments and markets

The Colombian government and its financial sector have been at the forefront of the development of climate finance instruments. After establishing a green bond framework compliant with the International Capital Market Association's Green Bond Principles, Colombia issued its inaugural sovereign green bond in pesos in 2021, the first such issuance in Latin America. Raising the equivalent of US\$850 million, or about 0.2 percent of GDP across issuances, at a lower yield than comparable "non-green" issuances, the proceeds financed the green agenda. Since 2016, the Colombian private sector—primarily financial institutions—has issued approximately US\$880 million of sustainable and green bonds in Colombia.

However, green bond issuances and credit, and other green capital market instruments, remain below their potential. The number of private sustainable and green bond issuances has remained modest—5 sustainability bonds and 10 green bonds. In the credit market, Colombia's financial sector lent out US\$123 billion in 2021 (Asobancaria 2021). Of this, 2.4 percent, or US\$3 billion, was rated as "green" finance using the criteria of Colombia's green taxonomy.⁴⁴ Although the green taxonomy is not perfectly congruent with climate criteria, this is roughly equivalent to the US\$3 billion that the private sector would need to mobilize annually between 2023 and 2030 for the RNZP. However, 96 percent of current loans are concentrated in the transport, construction, energy, and water sectors. In light of the need for climate finance in the AFOLU sector—where concessional finance will be of particular importance given the small size of many producers—and in the waste and manufacturing sectors, additional financial products serving these sectors need to be rolled out. The banking and financial sector still face informational

⁴⁴Based on reporting from 12 financial institutions.

barriers that often prevent them from making informed decisions about climate investing, its benefits, and the technological components and steps required to take advantage of important reforms and recently promulgated standards.

Other green capital market instruments are also underdeveloped. Capital market instruments and vehicles such as blended-finance platforms, green infrastructure funds, green exchange trade funds, carbon credit markets, climate-linked bonds, and sustainability-linked bonds have not yet reached their full potential in Colombia. There are several reasons for this. A main one is the lack of awareness and understanding of these instruments among investors and issuers. Many investors in Colombia are still unfamiliar with the green taxonomy and related instruments. This lack of understanding makes it difficult for issuers to attract investors and raise funds for sustainable projects. Another reason for the underdevelopment of green capital market instruments is the limited pipeline of investment-ready projects that these instruments would finance. Sector platforms involving the real, finance, and public sectors can help resolve such bottlenecks and improve the quality of finance, and project preparation facilities can help build a pipeline of bankable projects.

Carbon markets are still in the early stages of development in Colombia, but NDBs could play a catalytic role in their development to improve the financial returns of climate investments. Colombia is developing a robust institutional and regulatory framework to govern the creation of environmental assets such as carbon credits. Beyond existing voluntary carbon markets, mainly based on forest carbon, future cashflows from the monetization of carbon credits could provide an important complement in the financing of sustainable infrastructure projects by improving financial returns and repayment periods. NDBs, because of their expertise in working with key sectors of the economy as well as the government and state-owned enterprises, are well placed to create platforms and co-invest with private funds and align new funds with government strategy. This would improve liquidity and monetization options for environmental assets.

The financial sector will play a major role in enabling the transition, especially if it can provide patient capital. Since green investments usually involve more extended payback periods, they require long-term financing. The Colombian financial sector is best placed to exploit these opportunities, and the role of NDBs is particularly important (see below). It will be important for patient financing to reach small- and medium-sized enterprises (SMEs) in a wide range of sectors. The participation of smaller firms in reaching net-zero commitments is crucial given their representation in key value chains for Colombia. However, the use of earmarking the borrowed funds for specific uses should be avoided in order not to generate distortions that could undermine productivity.

Despite all the achievements to date, the green financial sector could be developed further. Moving forward, the financial sector can leverage the green taxonomy and green bond frameworks to scale up climate finance for strategic areas, such as climate-smart agriculture and low-carbon infrastructure. At the same time, the financial sector superintendent can help banks map their green portfolios, overcome key challenges to green taxonomy implementation, and scale green investments. It is therefore crucial to further improve existing metrics and push for more transparency on the financial impact of climate change in investment portfolios. Mapping green portfolios should be done in parallel with risk assessments that include climate-related financial risks because scenario and impact analysis related to climate change is still a work in progress in the financial sector and, currently, financial institutions are not mandated to disclose their exposure to climate risks or climate opportunities. In line with the Roadmap for Greening the Financial Sector, the government needs to promote the economy-wide disclosure of the environmental, social, and governance (ESG) and climate-related performance of financial institutions using international standards such as the Sustainability Disclosure Standard. Improving metrics and increasing transparency facilitate the creation and adoption of climate finance instruments because local and foreign investors can better estimate the financial and environmental performance of their investments. In addition, board-level commitment is needed to define climate-related governance, strategy, opportunities, risk management, and metrics. The mandatory use of the green taxonomy would enable financial institutions to clearly identify green assets and disclose their green exposure.

Climate finance instruments should also take into consideration the different risk/return profile of potential investors, as well as the capacity of local firms to tap into financial markets. While large institutional investors such as pension funds and other financial institutions are better positioned to tap into climate finance instruments offered by capital markets (such as green bonds), a large share of the local private sector is composed of less sophisticated firms that may require a different set of instruments and incentive structures. In this context, it will be important to develop innovative new climate finance instruments, including de-risking structures, corporate loans, project finance loans, revolving credit facilities, and derivatives, as well as to provide technical assistance for developing investment-ready projects. NDBs have an important role to play here and could strengthen their leadership in mobilizing donor funding, public resources, and private capital, in particular by developing blended finance strategies to attract concessional finance to lower capital costs.

4.3.3. The role of the public sector in channeling funds

National development banks can play a critical role in delivering climate finance. First, compared to private investors, NDBs usually have a greater appetite for financing longer-term, higher-risk investments and can thus address critical market barriers associated with green investments, such as long payback periods and high perceived project risks. Second, NDBs can catalyze private finance for green activities by developing innovative approaches such as blended finance, co-financing, and de-risking instruments such as guarantees. Third, NDBs can help build a record on green investments by acting as a first mover and financing demonstration projects at the early stages of market development. Finally, NDBs can provide technical assistance and capacity building at all stages of project development (Dalhuijsen et al. forthcoming).

In Colombia, NDBs have begun to support the climate agenda, albeit with substantial variation among institutions (Arvai, Letelier, and Gutierrez 2022). Many NDBs are signatories to the Banking Association's Green Protocol, an initiative to support the integration of sustainability factors in the corporate governance of financial institutions and the development of new financial activities and products targeted at green development. In addition, some NDBs have benefitted from the support of global concessional funds to strengthen their climate risk management practices or to expand their product portfolio to include new green products and services. In 2021, 40 percent (US\$1.19 billion) of existing green finance in Colombia came from NDBs (Asobancaria 2021). This represented 18 percent of the new loans the four major NDBs⁴⁵ lent out that year (US\$6.7 billion). Assuming, for illustrative purposes, that each dollar of NDB investment leverages 3 dollars of additional private finance, this amount would in theory exceed the private financing requirements of the RNZP, provided it is effectively targeted.

To channel funds to the public sector at large for climate investments, the government has established the Sustainability and Climate Resilience Fund (*Fondo para la Sustentabilidad y la Resiliencia Climática*, FONSUREC). The 2022 tax reform earmarked 80 percent of carbon tax proceeds for climate action to be allocated through FONSUREC. However, with the current tax design, revenues are estimated to increase by only about 0.04 percent of GDP by 2028. Although it is foreseen that Colombia's emissions trading system will generate additional revenues for FONSUREC once it starts auctioning emission allowances, it is not expected that this will occur before 2026. The amount of finance mobilized through the emissions trading system will depend on the ongoing regulatory effort to define its scope, cap trajectory, and auction mechanism. However, given the need to link the carbon tax to the emissions trading system, the latter's ability to raise significant further resources will be limited as long as the carbon tax remains low. Much of FONSUREC's impact will therefore depend not only on the design of the carbon pricing regime, but also on its ability to efficiently allocate its resources to where the impact is highest, its ability to leverage private investment, and its capacity to create a pipeline of investable projects.

⁴⁵Based on a review of the 2021 annual reports of Bancoldex, FINAGRO, Findeter, and FDN, and assuming all institutions fully reported their green finance portfolio. Banco Agrario was excluded from the survey to avoid double-counting its financing with that of FINAGRO.

Colombia should leverage its PPP expertise to raise domestic and international private capital for climate action by ensuring that a robust regulatory framework and economic incentives are in place to accelerate the use of climate-focused PPPs. A regional leader in using PPP instruments (Economist Intelligence Unit 2019), Colombia procured over 200 PPP projects in infrastructure with a total value of US\$51 billion between 1990 and 2022—US\$27.5 billion for roads and US\$14.3 billion for electricity (World Bank 2023a). To catalyze investments in the climate transition, the government recently created the explicit possibility to develop PPPs for climate change projects. To accelerate the use of these instruments, the government, through institutions such as the National Development Finance Agency (*Financiera de Desarrollo Nacional*), can further encourage private sector involvement in climate-focused PPPs by (i) implementing a systematic screening process for climate risks and opportunities in project applications; (ii) structuring a robust pipeline of climate-smart projects, with well-informed and well-balanced climate risk allocation between public and private stakeholders; (iii) building on its past experience, especially in the road sector, and providing financial products that complement the market offer to mitigate specific risks that prevent additional investments; and (iv) developing blended finance vehicles that focus on mobilizing private capital while leveraging concessional resources to specifically cover the additional capital expenditures associated with climate mitigation and adaptation components.

4.3.4. The role of the external sector in channeling funds

Colombia has successfully accessed a mix of available climate financing. This includes dedicated climate finance, financing from the international private sector, carbon markets, and multilateral development bank (MDB) lending. Between 2016 and 2022, climate-tagged multilateral financing, which is contingent on advancing the legislative and regulatory agenda on climate, has amounted to US\$ 6.9 billion. FINDETER is an accredited entity of the Green Climate Fund (GCF) and FDN is seeking GCF accreditation. It is also identifying financing resources in the international market to implement blended finance structures, which would allow FDN to offer competitive financing for renewable energy projects—urban mobility, for example. It is also working to access GCF funds. Colombia is currently tapping into more than US\$ 100 million in targeted finance from the Climate Investment Funds. As mentioned in Section 3.1.1, Colombia could also tap international forest carbon finance.

5. Summary of Recommendations

This CCDR provides recommendations for how Colombia can approach realizing both its climate and development ambitions. This will require rationally managing climate-related physical, transitional, and financial risks. To propel the systems transformations required to implement the climate transitions, this CCDR puts forward policy *packages* centered on the priority sectors for the transitions. Each of the policy packages proposed in this CCDR is constituted by a selection of high-priority short-, medium-, and long-term policy actions that would support the country's resilient, low-carbon development ambitions. The policy packages and their specific policy actions all differ in their impacts on development and climate, and the country has varying levels of readiness for initiating them. In addition, each policy action will have to be assessed against several other challenges, among them resource and capacity constraints, and policy, institutional, and technological challenges. It is important to note that each policy action by itself does not constitute a silver bullet – to achieve the system-level changes required, the policy packages need to be implemented. Given the important role of the private sector, macroeconomic management, and institutional governance for the climate transitions, the CCDR also identifies cross-cutting policy packages that underpin success in the sectoral policy packages.

This summary attempts to provide a high-level prioritization of each policy action against these aspects but should be understood as a preliminary exercise that would benefit from a more in-depth analysis of institutional and regulatory framework conditions, as well as governance and political economy challenges, and cost-benefit analysis. Table 5.1 lays out the criteria used for assessing the recommended policy actions. Table 5.2 below provides the full list of policy packages and their underlying policy actions.

TABLE 5.1. Criteria for prioritizing recommended policy actions

	Criteria	Description
Climate impact	Adaptation	<ul style="list-style-type: none"> Reduction of vulnerability to climate risks
	Mitigation	<ul style="list-style-type: none"> Impact on emission reductions Potential to avoid lock-in
Development impact	Human capital	<ul style="list-style-type: none"> Impact on poverty reduction Employment generation potential
	Economic growth	<ul style="list-style-type: none"> Relevance to growth as measured by contribution to GDP
	Natural capital	<ul style="list-style-type: none"> Impact on conservation and restoration
Implementation readiness		<ul style="list-style-type: none"> Adequacy of policy framework
	Enabling architecture	<ul style="list-style-type: none"> Adequacy of institutional framework Availability of technology
	Financing	<ul style="list-style-type: none"> Impact on fiscal burden Suitability for private investment

Source: World Bank staff, adapted from World Bank (2022).

TABLE 5.2. Summary of policy packages and actions

Timeline urgency:
 **Short-Term = (2022/2023 to 2024/2025)**
 **Medium-Term = (2024/2025 to 2029/2030)**
 **Long-Term = (Beyond 2030)**

Policy area	Priority policy actions	Prioritization result	
1. Sustainable and Productive Landscapes			
a. Deforestation Control	<ul style="list-style-type: none">  Expand the multipurpose cadaster  Update land registration folios  Control establishment of new <i>veredas</i>  Introduce a livestock traceability system  Phase out incentives for unsustainable cattle ranching  Develop employment alternatives outside of land use sectors around deforestation hotspots  Align policies at national and decentralized levels  Scale up sustainable production and restoration  Conduct inclusive land use planning  Strengthen land and tenure rights for IPLCs  Increase extension services  Expand sustainable value chains for agricultural and forest products  Build capacity of Regional Environmental Authorities  Strengthen the National Parks Unit  Increase the effectiveness of law enforcement 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing
b. Climate-Smart Agriculture	<ul style="list-style-type: none">  Repurpose agricultural support towards green innovation  Strengthen the agricultural innovation system  Design financial products for technology adoption and improve risk management  Set targets for development banks to expand CSA lending and include climate criteria in lending decisions  Expand access to finance in rural areas, through FIs, bundled with technical assistance  Initiate partnerships to integrate digital solutions into producers' practices  Expand the provision of guarantees and agricultural insurance 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing
2. Low Carbon and Resilient Infrastructure			
a. Energy	<ul style="list-style-type: none">  Align electricity sector policies, planning and regulations with decarbonization objectives  Developing a climate-resilient electricity generation, transmission, and distribution system  Increase the share of renewable power generation  Increase energy efficiency uptake with a focus on buildings  Increase electrification of end uses (buildings and industry)  Develop regulation for production and use of low-carbon hydrogen 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing

Timeline urgency:

-  Short-Term = (2022/2023 to 2024/2025)
-  Medium-Term = (2024/2025 to 2029/2030)
-  Long-Term = (Beyond 2030)

Policy area	Priority policy actions	Prioritization result	
b. Transport	<ul style="list-style-type: none">  Investing in climate resilient rural roads in lagging regions  Strengthen regulatory framework and use of climate finance products designed to incentivize private investment in adaptation of primary roads.  Electrify public transport systems  Improve bankability of concession contracts in urban transport  Continue the modal shift toward active transportation  Develop policy and investment program for low carbon trucking  Implement multimodal freight projects 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing
c. Water	<ul style="list-style-type: none">  Invest in water supply, sanitation, and irrigation in lagging regions  Reduce fragmentation in water supply and sanitation services 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing
3. A People-Centered and Just Transition			
a. Social Protection	<ul style="list-style-type: none">  Expand coverage and amount of social assistance programs  Improve social assistance programs' delivery mechanisms  Link social assistance programs to economic inclusion strategies  Implement a dynamic household social registry  Integrate the social registry with early warning systems 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing
b. Job Transitions	<ul style="list-style-type: none">  Implement training and reskilling programs  Promote innovation in green technologies  Promote linkages between firms and research institutions  Implement compensatory transfers and insurance programs  Facilitate spatial reallocation of individuals 	<p> Development</p> <p> Climate</p> <p> Readiness</p>	<ul style="list-style-type: none">  Human Capital  Growth  Natural Capital  Adaptation  Mitigation  Enabling Architecture  Financing

Timeline urgency:

-  Short-Term = (2022/2023 to 2024/2025)
-  Medium-Term = (2024/2025 to 2029/2030)
-  Long-Term = (Beyond 2030)

Policy area	Priority policy actions	Prioritization result	
4. Macroeconomic Management			
	<ul style="list-style-type: none">  Increase the effective carbon price while protecting the poor  Compensation systems for the poorest to account for the effects of increasing the effective price of carbon  Increase collection of other taxes, reducing economic inefficiency and increasing progressivity  Reduce fuel subsidies  Increase spending efficiency to create fiscal space  Increase labor productivity in manufacturing 	<p>● ● ● Development</p> <p>● ● ● Climate</p> <p>● ● ● Readiness</p>	<ul style="list-style-type: none"> ● ● ● Human Capital ● ● ● Growth ● ● ● Natural Capital ● ● ● Adaptation ● ● ● Mitigation ● ● ● Enabling Architecture ● ● ● Financing
5. Private / Financial Sector Mobilization			
	<ul style="list-style-type: none">  Public development banks to implement the green taxonomy  Public development banks to expand blended finance products  Financial institutions to improve metrics for assessment and disclosure of climate-related financial risks  Promote use of international disclosure standards such as IFRS Sustainability Disclosure Standard  Financial institutions to define climate-related governance, strategy, opportunities, risk management, and metrics  Strengthen regulation to accelerate climate-focused PPPs  Develop innovative new climate finance instruments and use the Green Taxonomy  Strengthen carbon credit markets 	<p>● ● ● Development</p> <p>● ● ● Climate</p> <p>● ● ● Readiness</p>	<ul style="list-style-type: none"> ● ● ● Human Capital ● ● ● Growth ● ● ● Natural Capital ● ● ● Adaptation ● ● ● Mitigation ● ● ● Enabling Architecture ● ● ● Financing

Timeline urgency:

- 🕒 Short-Term = (2022/2023 to 2024/2025)
- 🕒 Medium-Term = (2024/2025 to 2029/2030)
- 🕒 Long-Term = (Beyond 2030)

Policy area	Priority policy actions	Prioritization result
6. Strengthening Coordination, Institutions and Capacity		
	<ul style="list-style-type: none"> 🕒 Improve coordination between national agencies to ensure climate policy alignment 🕒 Improve collaboration mechanisms between the central and decentralized levels 🕒 Develop a comprehensive program of measures to reach the NDC targets 🕒 Develop detailed implementation plans for all adaptation and mitigation actions with connected financing frameworks 🕒 Issue technical guidance and build capacity to ensure quality across territorial planning instruments 🕒 Mainstream adaptation into territorial planning 🕒 Bolster coordination between SISCLIMA and the National System for Disaster Risk Management 🕒 Strengthen subnational capacity for the implementation of adaptation measures 🕒 Conduct/update risk and vulnerability assessments to inform subnational government planning 🕒 Develop guidelines and methodologies to aid subnational adaptation planning 🕒 Develop template projects for climate adaptation 🕒 Monitor NDC and LTS achievement 	<p>●●● Development</p> <p>●●● Climate</p> <p>●●● Readiness</p> <p>●● Human Capital</p> <p>●●● Growth</p> <p>●●● Natural Capital</p> <p>●●● Adaptation</p> <p>●●● Mitigation</p> <p>●●● Enabling Architecture</p> <p>●● Financing</p>

References

- ACP (Colombian Petroleum Association). 2021. *Informe económico. Tendencias de inversión en exploración y producción (E&P) en Colombia 2020 y perspectivas 2021*. Vicepresidencia de Asuntos Económicos y Regulatorios Bogotá, D.C.: Asociación Colombiana del Petróleo. <https://acp.com.co/web2017/es/informes/691-informe-economico-tendencias-inversion-e-p-en-colombia-2020-y-perspectivas-2021/file>.
- Agwe, Jonathan N., Margaret Arnold, Piet Buys, Robert S. Chen, Uwe Klaus Deichman, Maxx Dilley, Oddvar Kjevstad, Arthur L. Lerner-Lam, Bradfield Lyon, and Gregory Yetman. 2005. *Natural Disaster Hotspots: A Global Risk Analysis*. Washington, D.C.: World Bank Group. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/621711468175150317/Natural-disaster-hotspots-A-global-risk-analysis>.
- Alatorre, José Eduardo, Karina Caballero, Jimmy Ferrer, and Luis Miguel Galindo. 2019. *El costo social del carbono: una visión agregada desde América Latina. Estudios del cambio climático en América Latina*. Santiago: Economic Commission for Latin America and the Caribbean (ECLAC). <https://hdl.handle.net/11362/44423>.
- Arvai, Zsofia, Raquel Alejandra Letelier, and Eva M. Gutierrez. 2022. *Colombia – Financial Sector Assessment: The Role of the State in the Provision of Financial Services*. Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/099835104192245861/P173142025ffb601f0be8e057c1cb8735fc>.
- Asobancaria. 2021. *Informe de Sostenibilidad 2021*. Bogotá, D.C.: Asobancaria. https://www.asobancaria.com/wp-content/uploads/2022/08/Asobancaria_Informe_Sostenibilidad_2021.pdf.
- Banco de la República. 2023. *Balanza de Pagos*. Banco de La República. 2023. <https://www.banrep.gov.co/es/estadisticas/balanza-pagos>.
- Banerjee, Onil, Martin Cicowiez, Renato Vargas, Carl Obst, Javier Rojas Cala, Andrés Camilo Alvarez-Espinosa, Sioux Melo, Leidy Riveros, Germán Romero, and Diego Sáenz. 2021. "Gross Domestic Product Alone Provides Misleading Policy Guidance for Post-Conflict Land Use Trajectories in Colombia." *Ecological Economics* 182 (April). <https://doi.org/10.1016/j.ecolecon.2020.106929>.
- Borras, Saturnino, Cristóbal Kay, Sergio Gómez, and John Wilkinson. 2013. "Acaparamiento de tierras y acumulación capitalista: aspectos clave en América Latina." *Revista Interdisciplinaria de Estudios Agrarios* 38 (April). http://bibliotecadigital.econ.uba.ar/download/riea/riea_v38_n1_04.pdf.
- BP. 2021. *Statistical Review of World Energy, 2021 (70th Edition)*. London: BP. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.
- Briceno-Garmendia, Cecilia, Wenxin Qiao, and Vivien Foster. 2023. *The Economics of Electric Vehicles for Passenger Transportation*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/handle/10986/39513>.
- Brichetti, Juan Pablo, Leonardo Mastronardi, Maria Eugenia Rivas Amiassorho, Tomás Serebrisky, and Ben Solís. 2021. *La Brecha de Infraestructura En América Latina y El Caribe*. Washington, D.C.: Inter-American Development Bank (IDB). <https://interactive-publications.iadb.org/La-brecha-de-infraestructura-en-América-Latina-y-el-Caribe>.
- Cardona, Omar Darío, Gabriel Bernal, José Daniel Pabón, Mabel Cristina Marulanda, Martha Liliana Carreño, D González, C Villegas, et al. 2021. *Estudio de Riesgo por Efectos del Cambio Climático y Medidas de Adaptación para la Estrategia a Largo Plazo E2050 de Colombia – Fase 1. Entregable 3: Informe con los resultados de la Propuesta de Medidas de Adaptación y Su Efecto En Reducción Del Riesgo*. Bogotá, D.C.: Ingeniar Risk Intelligence. https://www.minambiente.gov.co/wp-content/uploads/2021/10/Modelacion_Adaptacion_Riesgo_Colombia.pdf.
- CAT. 2022. "Colombia Climate Action Tracker." Climate Action Tracker. <https://climateactiontracker.org/countries/colombia/>.
- Cheston, Timothy, Patricio Goldstein, Timothy Freeman, Alejandro Rueda-Sanz, Ricardo Hausmann, Matha Shreyas Gadgin, Sebastian Bustos, Eduardo Lora, Sarah Bui, and Nidhi Rao. 2023. *Seeing the Forest for More than the Trees: A Policy Strategy to Curb Deforestation and Advance Shared Prosperity in the Colombian Amazon*. CID Faculty Working Paper. Cambridge, MA.: Center for International Development, Harvard University. <https://growthlab.cid.harvard.edu/sites/projects.iq.harvard.edu/files/growthlab/files/2023-02-cid-wp-430-colombia-amazonia-policy-report-en.pdf>.

- Climate Analytics. 2023. "Climate Impact Explorer: – Colombia." Climate Impact Explorer. <http://climate-impact-explorer.climateanalytics.org/>.
- Climate Watch. 2021. "Climate Watch Database: Historical GHG Emissions – Colombia." *Climate Watch*. https://www.climatewatchdata.org/ghg-emissions?end_year=2019&start_year=1990.
- Climate Watch. 2022. "Explore Long-Term Strategies – Colombia." *Climate Watch*. <https://www.climatewatchdata.org/lts-explore>.
- Corredor, Armando. 2016. *Empleo y productividad laboral agropecuaria en Colombia*. Macroeconomía del Desarrollo. Santiago: Economic Commission for Latin America and the Caribbean (ECLAC). <https://www.cepal.org/es/publicaciones/40709-empleo-productividad-laboral-agropecuaria-colombia>.
- CPLC (Carbon Pricing Leadership Coalition). 2017. *Report of the High-Level Commission on Carbon Prices*. Washington, D.C.: World Bank Group. https://static1.squarespace.com/static/54ff9c5ce4b0a53deccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf.
- Dalhuijsen, Emma, Eva Gutierrez, Martijn Gert Jan Regelink, Rachel Mok, and Tatsiana Kliatskova. Forthcoming. *Greening National Development Financial Institutions: Trends, Lessons Learned and Ways Forward*. Washington, D.C.: World Bank Group.
- DANE (National Administrative Department of Statistics). 2018. "Censo Nacional de Población y Vivienda – CNPV – 2018." Archivo Nacional de Datos (ANDA). <https://microdatos.dane.gov.co/index.php/catalog/643>.
- DANE (National Administrative Department of Statistics). 2021a. *Cuentas Nacionales Departamentales: PIB Por Departamento. Sistema de Cuentas Nacionales*. Departamento Administrativo Nacional de Estadística. <https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-departamentales>.
- DANE (National Administrative Department of Statistics). 2021b. *Estadísticas de Comercio Internacional*. Departamento Administrativo Nacional de Estadística. <https://www.dane.gov.co/index.php/estadisticas-por-tema/comercio-internacional>.
- DANE (National Administrative Department of Statistics). 2021c. *Mercado Laboral. Población Ocupada Según Rama de Actividad*. Departamento Administrativo Nacional de Estadística. <https://www.dane.gov.co/index.php/estadisticas-por-tema/mercado-laboral/empleo-y-desempleo>.
- DANE (National Administrative Department of Statistics). 2022a. *Cuenta Satélite Ambiental (CSA)*. Departamento Administrativo Nacional de Estadística. <https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-satelite/cuenta-satelite-ambiental-csa#cuenta-ambiental-y-economica-de-activos-de-los-recursos-minerales-y-energeticos-cae-arme>.
- DANE (National Administrative Department of Statistics). 2022b. *Encuesta de Micronegocios*. Departamento Administrativo Nacional de Estadística <https://www.dane.gov.co/index.php/estadisticas-por-tema/mercado-laboral/micronegocios>.
- DANE (National Administrative Department of Statistics). 2022c. *Gran Encuesta Integrada de Hogares*. Departamento Administrativo Nacional de Estadística. <https://www.dane.gov.co/index.php/estadisticas-por-tema/mercado-laboral>.
- DANE (National Administrative Department of Statistics). 2023. *Boletín Técnico. Gran Encuesta Integrada de Hogares (GEIH): Ocupación Informal*. https://www.dane.gov.co/files/investigaciones/boletines/ech/ech-informalidad/bol_geih_informalidad_dic22_feb23.pdf.
- Dávalos, Liliana M., Jennifer S. Holmes, Nelly Rodríguez, and Dolores Armenteras. 2014. "Demand for Beef Is Unrelated to Pasture Expansion in Northwestern Amazonia." *Biological Conservation* 170 (February). <https://doi.org/10.1016/j.biocon.2013.12.018>.
- Dávalos, Maria Eugenia, Juan Manuel Monroy Barragan, Luz Stella Rodríguez, and Carlos Eduardo Manrique. 2023. *Adaptive Social Protection in Colombia: What Is the Distributional Impact of Shocks and How Can the Social Protection System Better Respond? An Application of the Social Protection Stress Test Tool*. Washington, D.C.: World Bank Group. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099544303222329925/IDU098bd5f650b748042be098e102af600756033>.

- Gallego Serna, Lina María, Carolina Díaz Giraldo, and Lina María Ibatá Molina. 2020. *Gastos de Inversión Pública Para El Financiamiento de La Gestión Del Riesgo de Desastres En El Orden Nacional y Subnacional Para El Periodo 2011-2019 En Colombia*. Archivos de Economía. Bogotá, D.C.: Departamento Nacional de Planeación (DNP). <https://colaboracion.dnp.gov.co/CDT/Estudios%20Economicos/523.pdf>.
- Gautam, Madhur, David Laborde, Abdullah Mamun, Will Martin, Valeria Pineiro, and Rob Vos. 2022. *Repurposing Agricultural Policies and Support: Options to Transform Agriculture and Food Systems to Better Serve the Health of People, Economies, and the Planet*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/handle/10986/36875>.
- Gaviria González, Natalia. 2022. "Según Minagricultura cerca de 15% del sector agro utiliza tecnología de última generación." *Agronegocios*. February 2022. <https://www.agronegocios.co/agricultura/segun-minagricultura-cerca-de-15-del-sector-agro-utiliza-tecnologia-de-ultima-generacion-3299246>.
- Gómez-Lobo, Andrés. 2020. "Transit Reforms in Intermediate Cities of Colombia: An Ex-Post Evaluation." *Transportation Research Part A: Policy and Practice* 132 (February). <https://doi.org/10.1016/j.trra.2019.11.014>.
- González Arenas, José Julian, Álvaro Cubillos Buitrago, María Alejandra Chadid Hernández, Alexander Cubillos González, Miguel Arias Patiño, Edilneyi Zúñiga Avirama, Fanny Joubert, Ivan Roberto Pérez Vizcaíno, and Viviana Berrío Meneses. 2018. *Caracterización de las Principales Causas y Agentes de la Deforestación a Nivel Nacional. Periodo 2005-2015*. IDEAM, MADS, United Nations. <https://www.fao.org/publications/card/es/c/19618ES/>.
- Government of Colombia. 2018. *Bosques Territorios de Vida. Estrategia Integral de Control a la Deforestación y Gestión de los Bosques*. Bogotá, D.C.: Ministerio de Ambiente y Desarrollo Sostenible (MADS). <https://www.minambiente.gov.co/wp-content/uploads/2021/10/Estrategia-Integral-de-control-a-la-Deforestacion-y-Gestion-de-los-Bosques.pdf>.
- Government of Colombia. 2020. *Actualización de La Contribución Determinada a Nivel Nacional de Colombia (NDC)*. Bogotá, D.C.: United Nations Framework Convention on Climate Change (UNFCCC). <https://unfccc.int/sites/default/files/NDC/2022-06/NDC%20actualizada%20de%20Colombia.pdf>.
- Government of Colombia. 2021. *Estrategia Climática de Largo Plazo de Colombia E2050 Para Cumplir Con El Acuerdo de París*. Bogotá, D.C.: United Nations Framework Convention on Climate Change (UNFCCC). https://unfccc.int/sites/default/files/resource/COL_LTS_Nov2021.pdf.
- Government of Colombia. 2022. *BUR 3. Tercer informe bienal de actualización de cambio climático de Colombia*. Bogotá, D.C.: United Nations Framework Convention on Climate Change (UNFCCC). <https://unfccc.int/sites/default/files/resource/BUR3%20-%20COLOMBIA.pdf>.
- Government of Colombia, WWF (World Wildlife Fund), and FCDS (Foundation for Conservation and Sustainable Development). 2020. *Lineamientos de Infraestructura Verde Vial Para Colombia (LIVV)*. Bogotá, D.C.: Ministerio de Ambiente y Desarrollo Sostenible (MADS). <https://www.minambiente.gov.co/wp-content/uploads/2022/07/24.-Lineamientos-de-infraestructura-verde-vial-para-Colombia.pdf>.
- Guha-Sapir, D., R. Below, and Ph Hoyois. 2022. "EM-DAT: The CRED/OFDA International Disaster Database." EM-DAT: The International Disaster Database. www.emdat.be.
- Guzman, Luis A., Julian Arellana, Daniel Oviedo, Daniela Castaño Herrera, and Olga L. Sarmiento. 2023. "Lifting Urban Mobility for the Poor: Cable-Cars, Travel Satisfaction and Subjective Well-Being." *Transportation Research Part D: Transport and Environment* 119 (June): 103765. <https://doi.org/10.1016/j.trd.2023.103765>.
- Hallegatte, Stephane, Jun Rentschler, and Julie Rozenberg. 2020. *Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience*. Washington, D.C.: World Bank Group. <https://doi.org/10.1596/34780>.
- Hertel, Thomas W. 2012. *Implications of Agricultural Productivity for Global Cropland Use and GHG Emissions: Borlaug vs. Jevons*. GTAP Working Paper. West Lafayette, IN.: Center for Global Trade Analysis, Purdue University. <https://www.gtap.agecon.purdue.edu/resources/download/6110.pdf>.
- IDEAM (Institute of Hydrology, Meteorology and Environmental Studies). 2017. *Análisis de Vulnerabilidad y Riesgo Por Cambio Climático En Colombia: Tercera Comunicación Nacional de Cambio Climático*. Bogotá, D.C.: IDEAM. https://www.researchgate.net/publication/322220463_Analisis_de_Vulnerabilidad_y_Riesgo_por_Cambio_Climatico_en_Colombia_Tercera_Comunicacion_Nacional_Cambio_Climatico_Colombia.

- IDEAM (Institute of Hydrology, Meteorology, and Environmental Studies). 2020. *Resultados Del Monitoreo de La Deforestación Bogotá, D.C.*: IDEAM. http://www.ideam.gov.co/documents/10182/113437783/Presentacion_Deforestacion2020_SMBByC-IDEAM.pdf/8ea7473e-3393-4942-8b75-88967ac12a19.
- IDEAM (Institute of Hydrology, Meteorology, and Environmental Studies). 2022. *Sistema de Monitoreo de Bosque y Carbono Bogotá, D.C.*: IDEAM. <http://www.ideam.gov.co/web/siac/smbyc>.
- IEA (International Energy Agency). 2021a. *World Energy Outlook 2021*. Paris: IEA <https://www.iea.org/reports/world-energy-outlook-2021>.
- IEA (International Energy Agency). 2021b. *Coal 2021. Analysis and Forecast to 2024*. IEA <https://iea.blob.core.windows.net/assets/f1d724d4-a753-4336-9f6e-64679fa23bbf/Coal2021.pdf>.
- IFC (International Finance Corporation). 2022. *Climate Smart Agriculture Market Study*. Background Note for Colombia CCDR. Washington, D.C.: World Bank Group.
- IFC. (International Finance Corporation). Forthcoming. *Economic Impact Assessment Framework*. Washington, D.C.: World Bank Group.
- ILO (International Labour Organization). 2019. *Working on a Warmer Planet. The Impact of Heat Stress on Labour Productivity and Decent Work*. ILO https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_711919.pdf.
- IMF (International Monetary Fund). 2022. "Trade in Environmental Goods." Climate Change Indicators Dashboard, October 2022. Washington, D.C.: IMF. <https://climatedata.imf.org/datasets/8636ce866c8a404b8d9baeaffa2c6cb3/explore>.
- INS (Instituto Nacional de Salud). 2018. *Carga de Enfermedad Ambiental: Décimo Informe Técnico Especial*. Bogotá, D.C.: Instituto Nacional de Salud, Observatorio Nacional de Salud.
- Insight Crime and Instituto Igarapé. 2022. "La Amazonía Saqueada: Las Raíces de Los Delitos Ambientales En Cinco Países." *Insight Crime*, November 2022. <https://es.insightcrime.org/investigaciones/amazonia-saqueada-raices-delitos-ambientales/>.
- International Crisis Group. 2021. *A Broken Canopy: Deforestation and Conflict in Colombia*. Latin America Report. Brussels: International Crisis Group. <https://icg-prod.s3.amazonaws.com/091-colombia-broken-canopy.pdf>.
- IPCC (Intergovernmental Panel on Climate Change). 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II. Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC. https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf.
- Johnson, Justin Andrew, Giovanni Ruta, Uris Baldos, Raffaello Cervigni, Shun Chonabayashi, Erwin Corong, Olga Gavryliuk, et al. 2021. *The Economic Case for Nature: A Global Earth-Economy Model to Assess Development Policy Pathways*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/handle/10986/35882>.
- Kulp, Scott, and Benjamin Strauss. 2019. "New Elevation Data Triple Estimates of Global Vulnerability to Sea-Level Rise and Coastal Flooding." *Nature Communications* no. 10 (October). <https://www.nature.com/articles/s41467-019-12808-z#Abs1>.
- MADR (Ministry of Agriculture and Rural Development). 2019. *Un Campo Para La Equidad. Política Agropecuaria y de Desarrollo Rural 2018-2022*. Bogotá, D.C.: Ministerio de Agricultura y Desarrollo Rural (MADR). https://sioc.minagricultura.gov.co/Documentos/20190326_politica_agro_2018-2022.pdf.
- MADS (Ministry of Environment and Sustainable Development) and DNP (National Planning Department). 2022. *Informe de Empalme Entre Gobiernos Nacionales*. Bogotá, D.C.: Ministerio de Ambiente y Desarrollo Sostenible. <https://www.minambiente.gov.co/wp-content/uploads/2022/07/Informe-de-Empalme-Ministerio-de-Ambiente-2018-2022-.pdf>.
- MHCP (Ministry of Finance and Public Credit). 2021. *Marco Fiscal de Mediano Plazo 2021*. Bogotá, D.C.: Ministerio de Hacienda y Crédito Público. https://www.minhacienda.gov.co/webcenter/ShowProperty?nodeId=%2FConexionContent%2FWCC_CLUSTER:165808%2F%2FidcPrimaryFile&revision=latestreleased.

- MHCP (Ministry of Finance and Public Credit). 2022. *Marco Fiscal de Mediano Plazo 2022*. Bogotá, D.C.: Ministerio de Hacienda y Crédito Público. https://www.minhacienda.gov.co/webcenter/ShowProperty?nodeld=%2FConexionContent%2FWCC_CLUSTER-197963%2F%2FidcPrimaryFile&revision=1atestreleased.
- MME (Ministry of Mines and Energy). 2020. *Informe EITI Colombia. Vigencia 2019*. Bogotá, D.C.: Ministerio de Minas y Energía. https://www.eiticolombia.gov.co/media/filer_public/0d/e6/0de6e902-ca6b-4a69-a08f-643211ea5c5f/informe_eiti_col_2019.pdf.
- MME (Ministry of Mines and Energy). 2021a. *Hoja de Ruta Del Hidrógeno En Colombia*. Bogotá, D.C.: Ministerio de Minas y Energía. https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Hoja%20Ruta%20Hidrogeno%20Colombia_2810.pdf.
- MME (Ministry of Mines and Energy). 2021b. *Plan Integral de Gestión Del Cambio Climático Del Sector Minero Energético 2050*. Bogotá, D.C.: Ministerio de Minas y Energía. https://www.minenergia.gov.co/documents/6393/PIGCCme_2050_vf.pdf.
- MT (Ministry of Transport). 2022. *Colombia tiene 8.299 vehículos eléctricos en el Runt: 1.699 más de la meta del Plan Nacional de Desarrollo*. Ministerio de Transporte. <https://www.mintransporte.gov.co/publicaciones/11015/colombia-tiene-8299-vehiculos-electricos-en-el-runt-1699-mas-de-la-meta-del-plan-nacional-de-desarrollo/>.
- Murillo-Sandoval, Paulo J., John Kilbride, Elizabeth Tellman, David Wrathall, Jamon Van Den Hoek, and Robert E. Kennedy. 2023. "The Post-Conflict Expansion of Coca Farming and Illicit Cattle Ranching in Colombia." *Scientific Reports* 13 (February). <https://doi.org/10.1038/s41598-023-28918-0>.
- OECD (Organisation for Economic Co-operation and Development). 2020a. *Agricultural Policy Monitoring and Evaluation 2020*. Agricultural Policy Monitoring and Evaluation report. Paris: OECD. https://www.oecd-ilibrary.org/agriculture-and-food/agricultural-policy-monitoring-and-evaluation-2020_928181a8-en.
- OECD (Organisation for Economic Co-operation and Development). 2020b. *Agricultural Policy Monitoring and Evaluation 2020*. Paris: OECD. <https://doi.org/10.1787/928181a8-en>.
- OECD (Organisation for Economic Co-operation and Development). 2021a. "Net Effective Carbon Rates." OECD.Stat. <https://stats.oecd.org/index.aspx?DataSetCode=ECRS>.
- OECD (Organisation for Economic Co-operation and Development). 2021b. *Taxing Energy Use for Sustainable Development: Opportunities for Energy Tax and Subsidy Reform in Selected Developing and Emerging Economies*. Paris: OECD. <https://www.oecd.org/tax/tax-policy/taxing-energy-use-for-sustainable-development.htm>.
- OECD (Organisation for Economic Co-operation and Development). 2023. "Environmental Tax." OECD iLibrary. https://www.oecd-ilibrary.org/environment/environmental-tax/indicator/english_5a287eac-en.
- Pardo Martínez, Clara Inés, and Alexander Cotte Poveda. 2021. "The Importance of Science, Technology and Innovation in the Green Growth and Sustainable Development Goals of Colombia." *Environmental and Climate Technologies* 25 (1). <https://doi.org/10.2478/rtuct-2021-0003>.
- Patiño, Lourdes Isabel, Vicent Alcántara, and Emilio Padilla. 2021. "Driving Forces of CO2 Emissions and Energy Intensity in Colombia." *Energy Policy* 151 (April). <https://doi.org/10.1016/j.enpol.2020.112130>.
- Pigato, Miria A. 2019. *Fiscal Policies for Development and Climate Action*. International Development in Focus. Washington, D.C.: World Bank Group. <https://doi.org/10.1596/978-1-4648-1358-0>.
- Planas, María Alejandra, and Juan Cárdenas. 2019. "La matriz energética de Colombia se renueva." *BID. Energía para el Futuro* (blog). March 2019. <https://blogs.iadb.org/energia/es/la-matriz-energetica-de-colombia-se-renueva/>.
- Prem, Mounu, Santiago Saavedra, and Juan F. Vargas. 2020. "End-of-Conflict Deforestation: Evidence from Colombia's Peace Agreement." *World Development* 129 (May). <https://doi.org/10.1016/j.worlddev.2019.104852>.
- Ramirez-Villegas, Julian, Mike Salazar, Andy Jarvis, and Carlos E. Navarro-Racines. 2012. "A Way Forward on Adaptation to Climate Change in Colombian Agriculture: Perspectives towards 2050." *Climatic Change* 115 (May). <https://doi.org/10.1007/s10584-012-0500-y>.

- Reinders, Henk Jan, Martijn Gert Jan Regelink, Pietro Calice, and Mariana Escobar Uribe. 2021. *Not-So-Magical Realism: A Climate Stress Test of the Colombian Banking System*. Washington, D.C.: World Bank Group. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/957831635911537578/not-so-magical-realism-a-climate-stress-test-of-the-colombian-banking-system>.
- Rentschler, Jun, and Melda Salhab. 2020. "1.47 Billion People Face Flood Risk Worldwide: For over a Third, It Could Be Devastating." *Development and a Changing Climate* (World Bank blog). November 2020. <https://blogs.worldbank.org/climatechange/147-billion-people-face-flood-risk-worldwide-over-third-it-could-be-devastating>.
- Roe, Stephanie, Charlotte Streck, Robert Beach, Jonah Busch, Melissa Chapman, Vassilis Daioglou, Andre Deppermann, et al. 2021. "Land-Based Measures to Mitigate Climate Change: Potential and Feasibility by Country." *Global Change Biology* 27 (23). <https://doi.org/10.1111/gcb.15873>.
- Romero, Liliana, Wilson Mayoraga, Diego Torres, Claudia Rojas, and Gina Alba. 2018. "Costos de La Accidentalidad Vial En Colombia." *Fasecolda*. <https://fasecolda.com/cms/wp-content/uploads/2019/09/costos-de-la-accidentalidad-vial-en-colombia-2018.pdf>.
- Ruppert Bulmer, Elizabeth, Kevwe Pela, Andreas Eberhard-Ruiz, and Jimena Montoya. 2021. *Global Perspective on Coal Jobs and Managing Labor Transition out of Coal: Key Issues and Policy Responses*. Washington, D.C.: World Bank Group. <http://hdl.handle.net/10986/37118>.
- SGC (Servicio Geológico Colombiano). 2020. *Atlas Geoquímico de Colombia 2020*. Bogotá, D.C.: SGC. https://srvags.sgc.gov.co/Archivos_Geoportal/Amenaza_Sismica/Atlas_Geoquimico_2020/Completo/AtlasGeoquimico2020.pdf.
- Signoret, José, and Jorge Tovar. 2021. *A Diagnostic of Trade Competitiveness in Colombia*. Misión de Internacionalización. Bogotá, D.C.: Departamento Nacional de [://www.dnp.gov.co/DNPN/mision-internacionalizacion/Documents/English_version_studies/Trade_Competitiveness_Diagnostic.pdf](http://www.dnp.gov.co/DNPN/mision-internacionalizacion/Documents/English_version_studies/Trade_Competitiveness_Diagnostic.pdf).
- Simas, Moana, and Kirsten Wiebe. 2020. *Assessing the Job Impact of Stimulus Investments in Latin America and the Caribbean: Method for Estimating Direct and Indirect Impacts on Employment, Emissions to Air, and Land Use Indicators*. Washington, D.C.: World Bank Group.
- Stanley, Michael C, John E. Strongman, Rachel Bernice Perks, Helen Ba Thanh Nguyen, Wendy Cunningham, Achim Daniel Schmillen, and Michael Stephen McCormick. 2018. *Managing Coal Mine Closure: Achieving a Just Transition for All* Washington, D.C.: World Bank Group. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail>.
- Streck, Charlotte, David Landholm, Felipe Bravo, Gabriela Martinez de la Hoz, Ivan Palmegiani, Mithra Sanggeet, and Szymon Mikolajczyk. 2022. *Unlocking Nature-Based Solutions in Colombia. Technical Report*. Bogotá, D.C.: Climate Focus. <https://climatefocus.com/wp-content/uploads/2022/09/Unlocking-Nature-based-Solutions-Colombia-Technical-Report-V1.1.pdf>.
- UNDRR (United Nations Office for Disaster Risk Reduction). 2015. *Global Assessment Report on Disaster Risk Reduction 2015*. Geneva: UNDRR. <https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2015>.
- Uniandes. 2021. "Los cambios que necesita el sector agrícola de cara al cambio climático. Centro de objetivos de desarrollo sostenible para America Latina." *CODS*, May 2021. <https://cods.uniandes.edu.co/agricultura-cambio-climatico-america-latina/>.
- UNODC (United Nations Office on Drugs and Crime). 2022. *Colombia: Monitoreo de Territorios Afectados Cultivos Ilícitos 2021*. Bogotá, D.C.: UNODC https://www.unodc.org/documents/crop-monitoring/Colombia/INFORME_MONITOREO_COL_2021.pdf.
- UPME (Unidad de Planeación Minero Energética). 2019. *Plan Indicativo de Expansión de Cobertura de Energía Eléctrica. PIEC 2019-2023*. Bogotá, D.C.: UPME. http://www.upme.gov.co/Siel/Siel/Portals/0/Piec/Informacion_Base_PIEC_Dic302019.pdf.
- UPME (Unidad de Planeación Minero Energética). 2020. *Plan Energético Nacional 2020-2050. La Transformación Energética Que Habilita Desarrollo Sostenible*. Bogotá, D.C.: UPME. https://www1.upme.gov.co/DemandayEficiencia/Documents/PEN_2020_2050/Plan_Energetico_Nacional_2020_2050.pdf.

- UPME (Unidad de Planeación Minero Energética). 2022. *Balance Energético Colombiano – BECO Año 2021*. Bogotá, D.C.: UPME. <https://www1.upme.gov.co/DemandayEficiencia/Paginas/BECO.aspx>.
- UPRA (Unidad de Planificación Rural Agropecuaria). 2014. *Presentación Insitucional*. Bogotá, D.C.: UPRA. https://www.minagricultura.gov.co/Documents/UPRA_Oferta_Institucional.pdf.
- USDA (United States Department of Agriculture). 2023. "International Agricultural Productivity." *Economic Research Service*. <https://www.ers.usda.gov/data-products/international-agricultural-productivity/>.
- VITO (Vlaamse Instelling Voor Technologisch Onderzoek N.V.) and Uniandes. Forthcoming. *Opciones Para Lograr La Meta de Reducción de Emisiones de GEI de La NDC Colombiana*. Bogotá, D.C.: World Bank Group.
- WEF (World Economic Forum). 2020. *The Global Competitiveness Report 2019*. Geneva: WEF. https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf.
- World Bank. 2005. *World Development Report 2006: Equity and Development*. Washington, D.C.: World Bank Group. <https://doi.org/10.1596/978-0-8213-6249-5>.
- World Bank. 2015. *Colombia: Systematic Country Diagnostic*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/handle/10986/23111>.
- World Bank. 2019. *Silvopastoral Systems, a Powerful Approach for Cattle Ranching to Adapt to Climate Change*. Bogotá, D.C.: World Bank Group. <https://documents1.worldbank.org/curated/en/295291623048193452/pdf/Silvopastoral-Systems-a-Powerful-Approach-for-Cattle-Ranching-to-Adapt-to-Climate-Change.pdf>.
- World Bank. 2020. *Colombia Turning the Tide: Water Security for Recovery and Sustainable Growth*. Washington, D.C.: World Bank Group. <https://doi.org/10.1596/34452>.
- World Bank. 2021a. "Agriculture, Forestry, and Fishing, Value Added (% of GDP) – Colombia." World Bank Data. <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=CO>.
- World Bank. 2021b. *Building an Equitable Society in Colombia*. Washington, D.C.: World Bank Group. <https://documents1.worldbank.org/curated/en/686821635218586591/pdf/Main-Report.pdf>.
- World Bank. 2021c. *Climate Risk Country Profile Colombia*. Washington, D.C.: World Bank Group. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-07/15520-WB_Colombia%20Country%20Profile-WEB%20%283%29.pdf.
- World Bank. 2021d. *Supporting Transition in Coal Regions: A Compendium of the World Bank's Experience and Guidance for Preparing and Managing Future Transitions*. Washington, D.C.: World Bank Group. <http://hdl.handle.net/10986/35323>.
- World Bank. 2021e. *Colombia Public Finance Review*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/entities/publication/6f8a064e-6d0b-5e67-868e-744cccac6256>.
- World Bank. 2022a. *Application of the Adaptation Principles in Colombia*. Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2022b. "Climate Change Knowledge Portal." <https://climateknowledgeportal.worldbank.org/>.
- World Bank. 2022c. "Colombia – Vulnerability." *Climate Change Knowledge Portal*. <https://climateknowledgeportal.worldbank.org/country/colombia/vulnerability>.
- World Bank. 2022d. *Colombia: The First Sovereign Green Bond in Local Currency in Latin America*. Washington, D.C.: World Bank Group. <https://thedocs.worldbank.org/en/doc/bc687cc79a64b1640b0a1e7af7a56142-0340012022/original/WB-Colombia-Greenbond-CaseStudy-Final.pdf>.
- World Bank. 2022e. *Emergency Room Admissions Attributed to Extreme Temperatures in Colombia and Their Associated Cost* Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2022f. *Increasing Subnational Public Investment in Resilience and Adaptation* Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2022g. "World Bank Open Data." World Bank Data. 2022. <https://data.worldbank.org/>.
- World Bank. 2022h. *Colombia - Systematic Country Diagnostic Update: Together for a Better Future*. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/handle/10986/37619>.

- World Bank. 2022i. *Pakistan Country Climate and Development Report* CCDR. Washington, D.C.: World Bank Group. <https://openknowledge.worldbank.org/entities/publication/614ddc2b-ca31-53c9-b59c-6bf12a56d336>.
- World Bank. 2023a. "About Private Infrastructure Projects Database." <https://ppi.worldbank.org/en/about-us/about-ppi>.
- World Bank. 2023b. *Employment Implications of a Competitive and Just Transition towards a Less-Carbon Intensive Economy in Colombia* Background Note for Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2023c. *Energy Climate and Development* Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2023d. *Estimating Rural Accessibility to Basic Services and Climate Change Impacts in Colombia* Background Note for Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2023e. *Investment Cost and Economic Analysis for Colombia's Resilient Net Zero Pathway* Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2023f. *Land Grabbing, Deforestation, and Conversion to Pasture in the Northwestern Arc of the Colombian Amazon* Background Note for Colombia CCDR. Washington, D.C.: World Bank Group.
- World Bank. 2023g. "Name Withheld. Unpublished Confidential Document." Washington, D.C.: World Bank Group.
- World Bank. 2023h. *Realizing the Potential of Energy Efficiency in Latin America and the Caribbean* Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/099854005092338445/IDU0541d1c4104cfd0449a089b90f7882cb769c0>.
- World Bank. Forthcoming. *Country Economic Memorandum* Washington, D.C.: World Bank Group.
- World Bank. Unpublished. *Evaluación Mecanismo Colombiano de Compensación Impuesto al Carbono Establecido Decreto 926 de 2017 y Resultados Generales Impuesto al Carbono Establecido Ley 1819 de 2016* Washington, D.C.: World Bank Group.
- World Bank and DNP (National Planning Department). 2023. *Alternative Carbon Tax Scenarios for Colombia: Simulations Using the Climate Policy Assessment Tool* Background Note for the Colombia CCDR. Bogotá, D.C.: World Bank Group.
- World Bank and IFC (International Finance Corporation). 2022. *Estimation of Investment Needs on Climate Adaptation for the Road Infrastructure Sector, with a Focus in the Role of Private Financing* Background Note for the Colombia CCDR. Washington, D.C.: World Bank Group.
- WRI (World Resources Institute). 2022. "Forest Pulse: The Latest on the World's Forests." *World Resources Institute Global Forest Review*. <https://research.wri.org/gfr/latest-analysis-deforestation-trends>.
- WRI (World Resources Institute) and Climate Focus. 2022. *Sink or Swim: How Indigenous and Community Lands Can Make or Break Nationally Determined Contributions* Washington, D.C.: Forest Declaration Assessment. <https://climatefocus.com/publications/sink-or-swim-how-indigenous-and-community-lands-can-make-or-break-nationally-determined/>.
- WWF (World Wildlife Fund). 2021. *Gobernanza Transparente de Recursos Naturales Colombia. Reporte Final* Bogotá, D.C.: WWF. https://files.worldwildlife.org/wwfmsprod/files/Publication/file/38g4v7obkf_Reporte_Final_TGNR.pdf.

