TRANSPORTATION 2050

PATHWAYS TO DECARBONIZATION AND CLIMATE RESILIENCE IN LATIN AMERICA AND THE CARIBBEAN

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iaph, international association of ports and harbors
IRF International Road Federation, Fédération Routière Internationale, Federación Internacional de Carreteras
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Acronyms

ACA	Airport Carbon Accreditation
ACI	Airports Council International
ACI-LAC	Airports Council International – Latin America & the Caribbean
ADCOMs	Adaptation communications
AI	Artificial Intelligence
BC	Black carbon or soot
BCSD	Bias Correction and Spatial Downscaling
BEV	Battery Electric Vehicle
BRT	Bus Rapid Transit
CBI	Climate Bonds Initiative
CC	Climate Change
CITEPA	Interprofessional Technical Center for Studies on Air Pollution
CO	Carbon monoxide
CO2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSO	Chief Sustainability Officer
CTF	Clean Technology Fund
EEDI	Energy Efficiency Design Index
ELT	End-of-Life Tires
ESG	Environmental, Social, and Governance
ESI	Environmental Ship Index
ETS	Emissions Trading System
EU	European Union
GCF	Green Climate Fund

GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GtCO2	Gigatonnes of carbon dioxide
IAPH	International Association of Port Harbors
ICAO	International Civil Aviation Organization
ICT	Information and Communications Technology
IDB	Inter-American Development Bank
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies
IDF	Intensity-Duration-Frequency
IKI	International Climate Initiative
ILO	International Labor Organization
IMO	International Maritime Organization
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IRF	International Road Federation
ITF	International Transport Forum
ITS	Intelligent Transportation Systems
LAC	Latin America & the Caribbean
LCA	Life Cycle Assessment
LEZ	Low Emission Zone
LT-LEDS	Long-Term Low-Emission Development Strategies
MaaS	Mobility as a Service
MSMEs	Micro, Small and Medium-sized Enterprises
MtCO2	Million Tonnes of carbon dioxide
NAMAs	Nationally Appropriate Mitigation Actions

NAPAs	National Adaptation Programs of Action
NAPs	National Adaptation Plans
NBS	Nature Based Solutions
NDCs	Nationally Determined Contributions
NMHC	Non-Methane Hydrocarbons
NO2	Nitrogen Dioxide
NOx	Nitrogen Oxides
OECD	Organization for Economic Co-operation and Development
PHEV	Plug-in hybrid electric vehicle
PIANC	World Association for Waterborne Transport Infrastructure
PKM	Passenger-kilometer
PM	Particulate Matter
PMBE	Polymer Modified Bitumen Emulsion
PMR	Partnership for Market Readiness
PPCR	Pilot Program for Climate Resilience
PPP	Public-Private Partnerships
R&D	Research and Development
RCP	Representative Concentration Pathways
RENAMI	National Registry of Mitigation Measures
SAF	Sustainable Aviation Fuels
SDGs	Sustainable Development Goals
SEEMP	Ship Energy Efficiency Management Plan
SIAT-NDC	System for Information on Advances in Transparency
SIDS	Small Island Developing States
SIIVRA	Sub-system on Information on Vulnerability, Risk and Adaptation
SINAMECC	National Climate Change Metrics System
SOE	State-Owned Enterprise

SREP	Scaling Up Renewable Energy Program in Low-Income Countries
SSP	Shared Socioeconomic Pathways
SUMP	Sustainable Urban Mobility Plans
Tasmax	Daily maximum near-surface air temperature
TCFD	Task Force on Climate Related Financial Disclosures
TfL	Transport for London
TKM	Tonne-kilometer
TOD	Transit-Oriented Development
TTW	Tank to Wheel
UITP	International Association of Public Transport
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WTT	Well to Tank
WWF	World Wildlife Fund

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Executive Summary

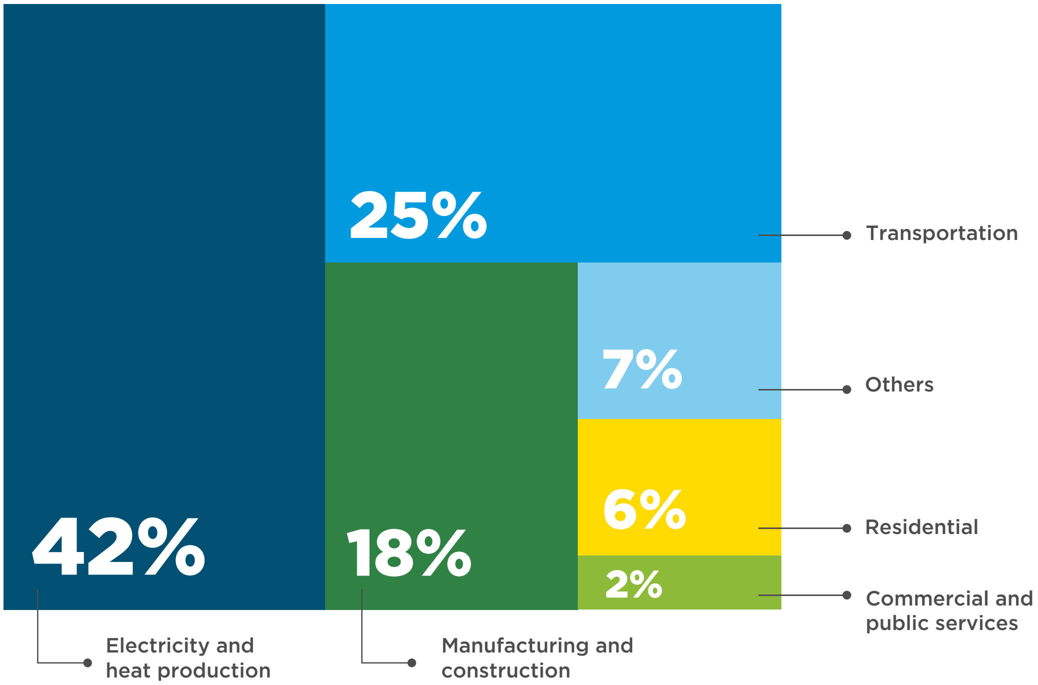
The transportation sector plays a key role in socio-economic development by facilitating the movement of people and goods. Transportation affects socio-economic development both directly and indirectly through different channels, ranging from the logistics costs faced by firms when transporting goods, to the effect on quality of life for public transportation users with access to efficient and high-quality services. Transportation influences 76 targets of the Sustainable Development Goals (SDGs), distributed over 17 SDGs (45%) (UNOPS et al., 2021). More specifically, it is a catalyzer to improve social inclusion and equity throughout the region, enabling access to job opportunities, health, and education for vulnerable populations, thus contributing to breaking the cycle of poverty and inequality (Scholl et al., 2022). At the same time, investing in infrastructure, with its positive effects on employment, accessibility, and economic development, is key to achieve SDGs. In this sense, it is estimated that if Latin America and the Caribbean (LAC) were to invest 1.4% of its Gross Domestic Product (GDP) annually until 2030, the region could close road, airport, and public transportation infrastructure gaps, advancing in the fulfillment of these objectives (Brichen et al., 2021).

Transportation plays a dual role in climate change (CC) (see Chapter 1). On one hand, at 25% of global emissions, transportation is the second largest Carbon Dioxide (CO2) contributor from the burning of fuel, after power generation and heating systems (Figure S.1.a). Additionally, the volume of emissions from the sector has significantly increased in recent decades, rising from 4.6 Gigatonnes of Carbon Dioxide (GtCO2) in 1990 to 8.3 GtCO2 in 2019 (Figure S.1.b). On the other hand, the transportation sector is highly vulnerable to the effects of CC. Increments in the intensity and frequency of extreme weather events cause infrastructure damages and service interruptions, which translate into higher economic and social costs.

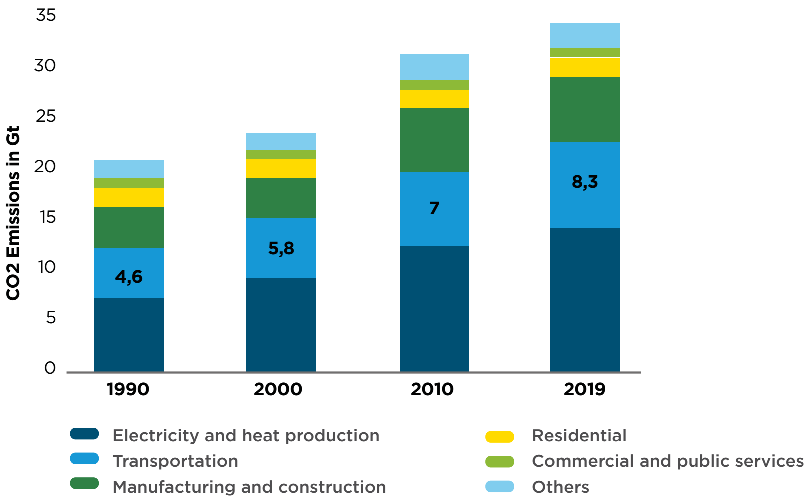
FIGURE S.1.

Global CO2 emissions derived from fuel combuistion by sector in 1990, 2000, 2010, and 2019

S.1.a
Share (2019)



S.1.b
Total emissions (1990-2019)

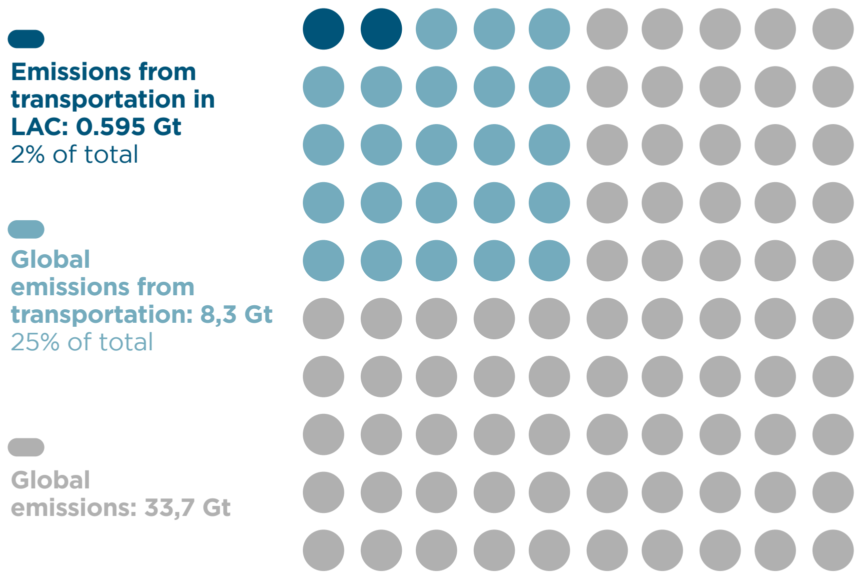


Source: Prepared by the authors based on data from IEA (2022f).

Note: Emissions from the transportation sector include those proceeding from maritime bunkers and aviation (fuel consumed by international transport).

Globally, countries in LAC have a limited participation on total CO2 emissions from the transportation sector. The region represents 9% of global transportation emissions (2% considering emissions from all sectors, Figure S.2.), compared to 32% from Asia-Pacific and 28% from North America. Per capita, the average CO2 emissions from LAC stood at 0.95 tons in 2019, above China and slightly above the global average (0.9 tons per capita), albeit well below the average of the Organization for Economic Co-operation and Development (OECD) countries and the United States, which reached 2.6 and 5.4 tons per capita, respectively. However, in line with global evolution, the region's emissions from transportation have been growing, reaching 595 million metric tons of carbon dioxide equivalent (MtCO2) in 2019, from 281 MtCO2 in 1990. Likewise, the region's participation in the global total went from 7% to 9% between 1990 and 2019, while North America and Europe saw significant reductions (-11 and -7 percentage points, respectively) (Figure S.3). Nevertheless, it is worth noting that LAC is far from the growth levels seen in Asia-Pacific, a region which doubled its global participation in three decades.

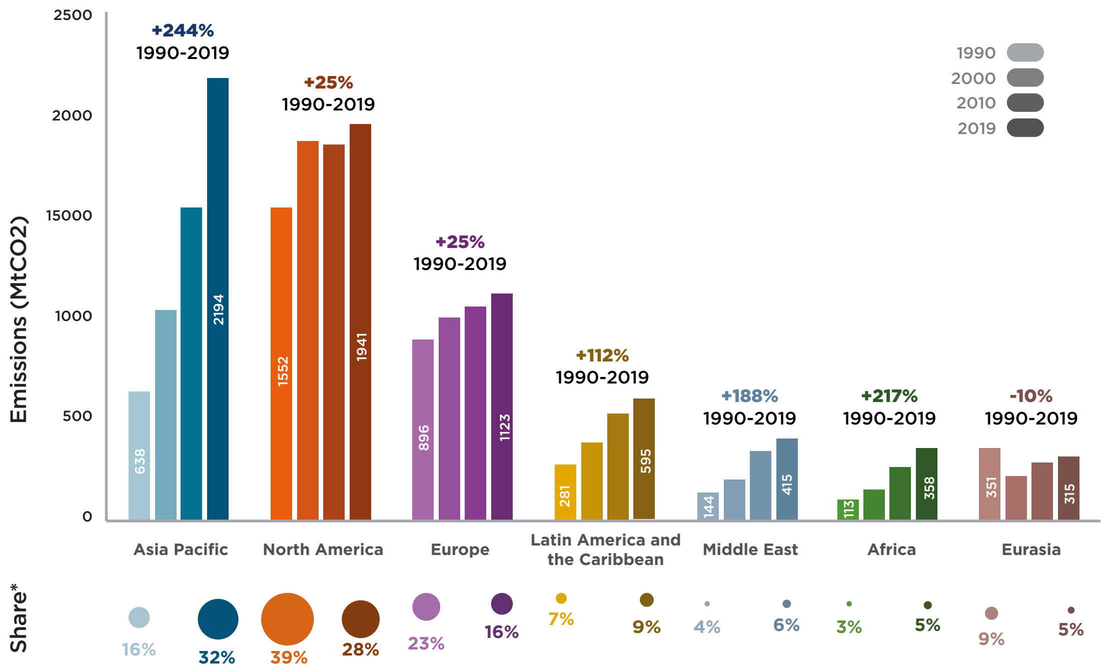
FIGURE S.2. **Global and LAC emissions from the transportation sector as a percentage of total emissions (2019)**



Source: Prepared by the authors based on data from IEA (2022f).

Note: LAC's regional figure does not include emissions from maritime bunkers or aviation, or pipeline transportation.

FIGURE S.3. **Historical emissions from the transportation sector by region (1990-2019)**



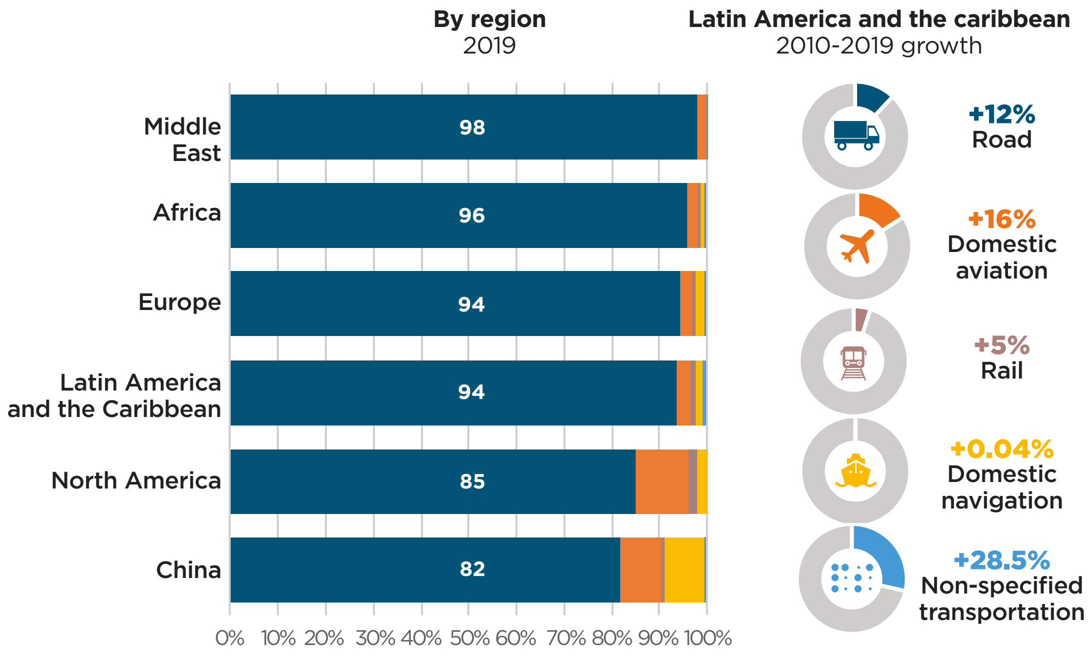
Source: Prepared by the authors based on data from IEA (2022g, 2022f, 2022e).

Note: Figures in millions of tons of CO2 – MtCO2. Maritime bunkers and aviation emissions are not included as they cannot be allocated to national or regional level (1.3 GtCO2 of the total 8.3 GtCO2 global emissions from the transportation sector in 2019). The division of countries in regions was done according to IEA (2023c), except for Mexico, which was classified in LAC.

The transportation sector is the main source of CO2 emissions in the region, representing 40% of total emissions. Road transportation is the top contributor to transportation emissions, representing up to 92% of the sector's total. Domestic aviation contributes 4%, domestic navigation 2%, and rail transportation 1% (Figure S.4). Most emissions stem from passenger transportation, which represent 56% of the sector's emissions. Of these, 46% come from land transportation and 9% from air transportation (Figure S.5).

FIGURE S.4.

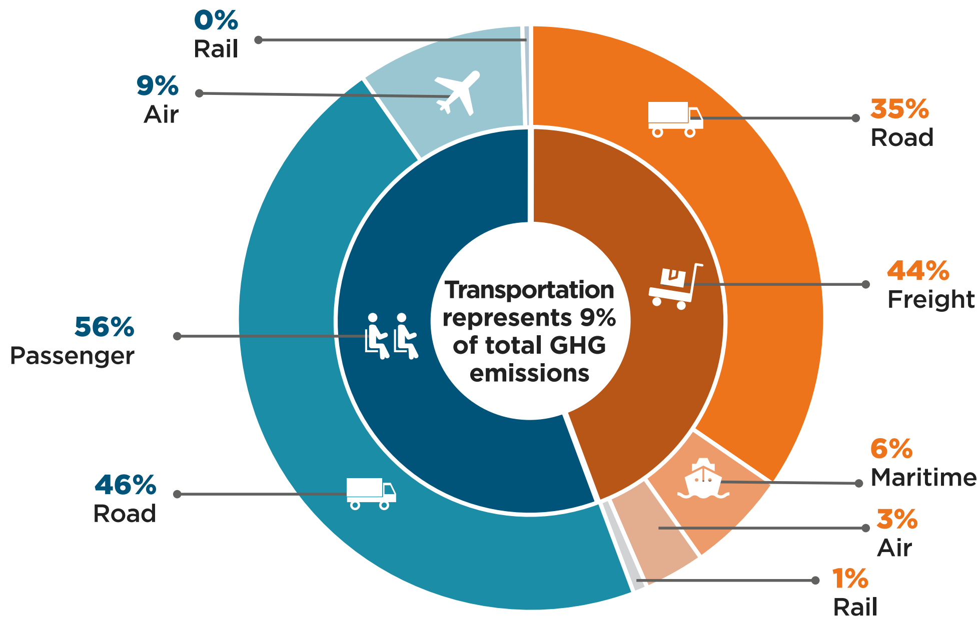
Distribution of CO2 emissions by transportation mode for each region and evolution by transportation mode for LAC



Source: Prepared by the authors based on data from IEA (2022g, 2022f, 2022e).

Note: The assessment by region and mode does not include emissions from maritime bunkers or aviation, or pipeline transportation.

FIGURE S.5. Emissions by transportation mode in LAC (2019)

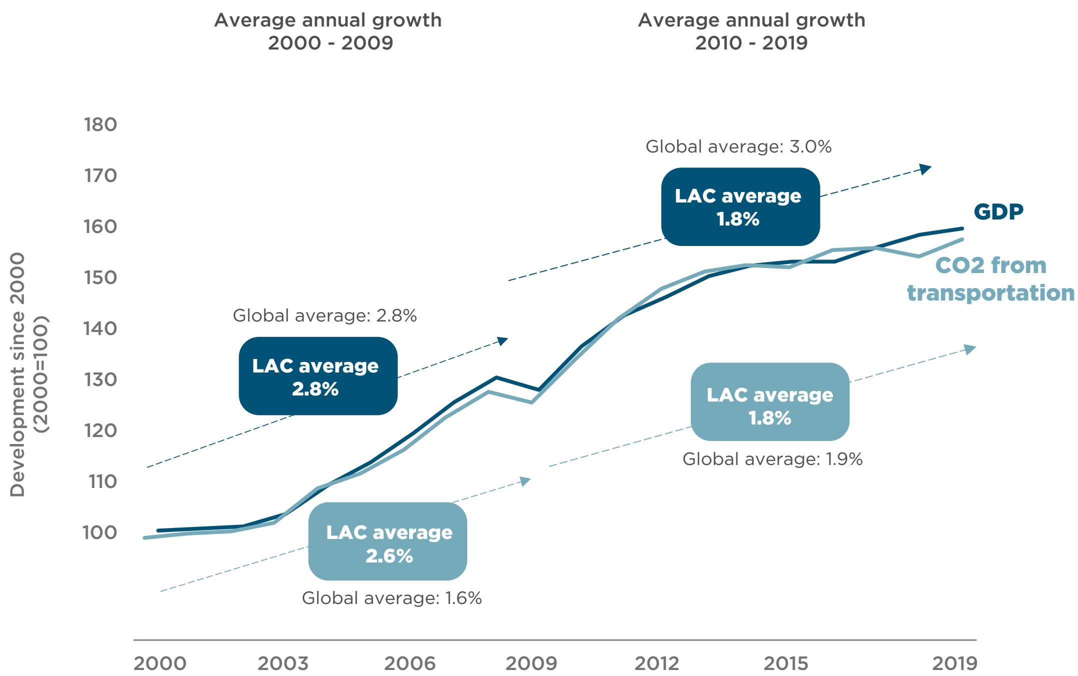


Source: Prepared by the authors based on data projected by ITF (2023a).
Note: Percentages in the figure refer to Tank-to-wheel emissions. Air freight transportation does not include cargo on passenger flights.

In the region, economic growth and transportation CO2 emissions are coupled. Over the 2000-2009 period, average annual GDP growth in LAC was 2.8%, while emissions from transportation rose by 2.6%. Similarly, during the 2010-2019 period, both GDP and transportation emissions increased by an average of 1.8% (Figure S.6). Road transportation was the main generator of these emissions. This coupling represents a significant challenge for the region and for developing countries overall. Advanced economies grew based on a carbon-intensive model (Awaworyi Churchill et al., 2021). On the other hand, developing countries face the challenge of boosting growth in the context of CC. Thus, the key question is how to reconcile economic growth with the energy transition.

FIGURE S.6.

Coupling between CO2 emissions from transportation and GDP in LAC (2000-2019)



Source: Prepared by the authors based on data from SLOCAT (2021b), IEA (2022g) y the World Bank (2023a).

Note: Analyzed LAC countries are: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, and Uruguay. Venezuela is not included due to lack of GDP data for this period. Global averages encompass all countries, including those of LAC.

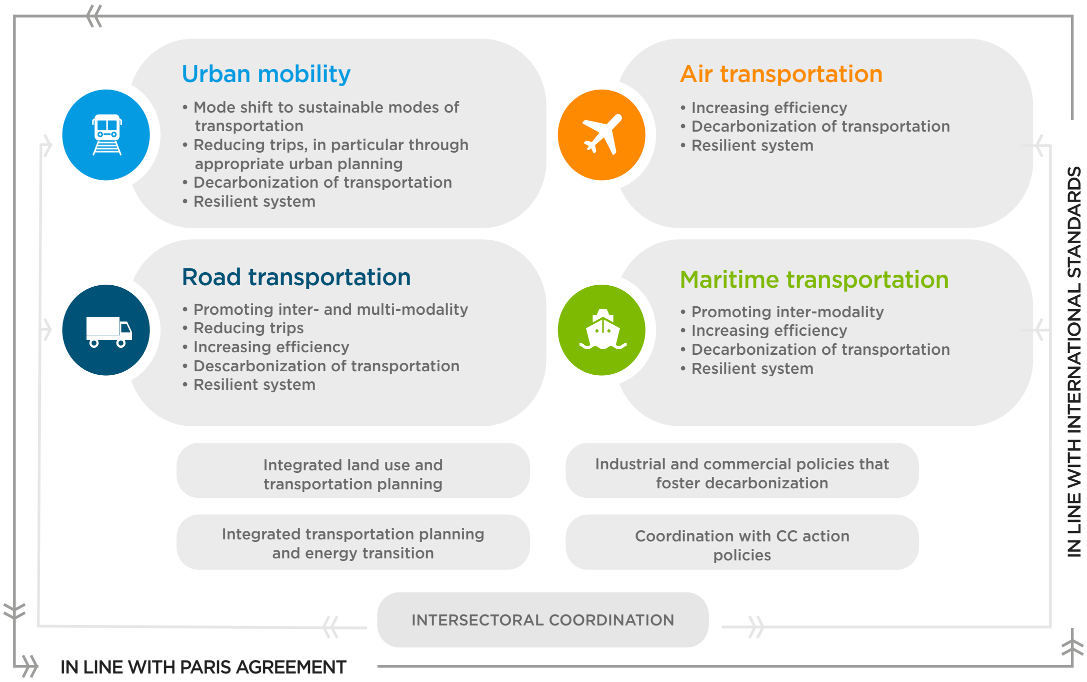
The Paris Agreement recognizes the need for a just transition, pointing out that the economic, social, and environmental context of each country must be taken into consideration, and emphasizing the adoption of a step-by-step approach for developing countries. To fight against the threat that CC poses for life, 196 countries signed the Paris Agreement in 2015, in the context of the United Nations Framework Convention on Climate Change (UNFCCC). This binding agreement brings together joint efforts by signatory nations to limit global warming to below 2 degrees Celsius – preferably 1.5 degrees Celsius – compared to preindustrial levels (UNFCCC, 2022). A just transition under the Paris Agreement implies recognizing that not all countries should move at the same pace towards decarbonizing their economies. Countries with higher levels of emissions and greater availability of resources should have greater responsibility for accelerating the transition. Indeed, the richest 1% in the world is responsible for 17% of global CO2 emissions; the next 9% accounts for 31.8%;

the middle 40% is responsible for 40% of global emissions; and the poorest 50% accounts for no more than 12% (UNCTAD, 2022a). Therefore, advanced economies should begin by making the largest effort by 2030, allowing developing countries to transition gradually towards a low-carbon growth model. With the corresponding delay, this pattern should also be replicated at regional level. Since relatively wealthier economies are also responsible for a larger share of the region's emissions, they are expected to be at the forefront of emission reductions in LAC.

The region should invest more and better in infrastructure to close the development gap and achieve SDGs. SDGs set up a framework for moving towards sustainable transport systems. Transportation contributes directly to five goals linked to road safety (target 3.6), energy efficiency (SDG 7.3), sustainable infrastructure (target 9.1), urban access (target 11.2), and fossil fuel subsidies (target 12.c). In addition, transportation indirectly contributes to agricultural productivity (target 2.3), environmental pollution (target 3.9), access to drinking water (target 6.1), sustainable cities (target 11.6), reducing food waste (target 12.3), and CC adaptation and mitigation (targets 13.1 and 13.2) (SLOCAT, 2023). Indeed, infrastructure and transportation services are key to build more inclusive and sustainable societies (Serebrisky et al., 2020). In LAC, mass public transportation systems increase access to employment and education, while investing in road infrastructure reduces travel times and costs of transporting goods and inputs, boosts productivity, improves market access, creates job opportunities, and increases the income of population benefiting from these investments, which contributes to reducing poverty. To generate these benefits, while the region meets its emission reduction goals in the context of a just transition, it will be crucial to increase investments, improve expenditure efficiency, and boost private participation in the sector.

The climate crisis provides an opportunity to bet on a new transportation model that improves equity and people's quality of life. Taking advantage of this opportunity requires developing a systemic vision of change, not only aiming at replacing fossil fuels for electric power, but also at achieving more sustainable, efficient, safe, and inclusive transportation, which provides access to opportunities for all (Figure S.7). To this end, it is vital to change the way people and goods move, based on specific strategies for each mode of transportation, coordination of actions in other government areas, and under the umbrella of a national plan that establishes the general vision and guidelines for the sector.

FIGURE S.7. **Transportation and climate change – a systemic vision**

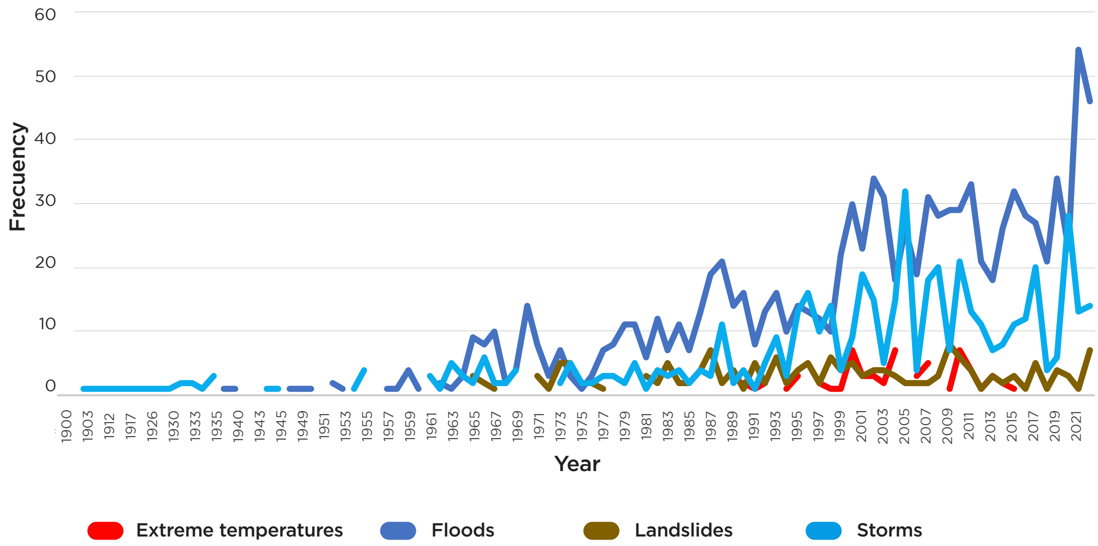


Source: Prepared by the authors.
Note: The figure considers the most relevant transportation subsectors for the region.

The systemic vision also involves reinforcing the climate resilience of transportation. The region is deeply affected by the negative effects of CC (IEA, 2022g; IPCC, 2014a). The region's average temperature went from rising 0.1°C every ten years between 1961 and 1990, to growing 0.2°C every ten years between 1991 and 2021, while the average sea level is rising at higher rates than the global average (WMO, 2022). LAC is increasingly experiencing natural disasters (Figure S.8), with countries like Brazil, Colombia, Mexico, Peru, Argentina, and Haiti accounting for the highest frequency of such disasters. The impact of extreme weather events on transportation systems is causing huge losses for the region, especially in lower-income countries and vulnerable populations that, in turn, have greater difficulty recovering.

The transportation sector is the largest source of CO_2 emissions in the region, representing 40% of total emissions. Road transportation accounts for 92% of total emissions, domestic aviation for 4%, domestic navigation for 2%, and rail transportation for 1%.

FIGURE S.8. **Historic evolution of the annual frequency of floods, storms, landslides, and extreme temperatures in LAC (1900-2021)**



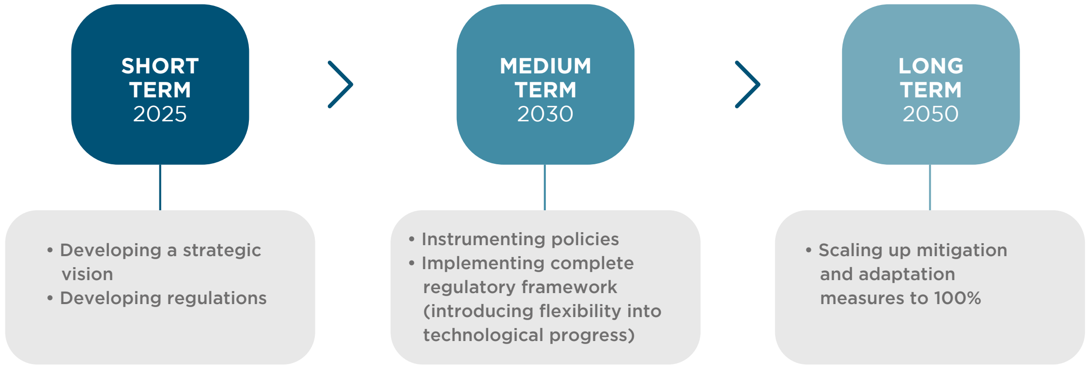
Source: Prepared by the authors based on data on natural disasters from EM-DAT (2023).

This situation will only worsen if decisive actions are not taken (see Chapter 2). According to the authors' calculations, with regard to air transportation, the exposure of airports to rising sea levels could affect tourism as well as the connectivity of certain areas, especially on island countries. In maritime transportation, projected sea level rise could potentially affect key ports in regional maritime networks, such as those of Panama and Cartagena. Similarly, projected sea level rise could affect most Central American ports, posing a significant risk for this subregion's economic activities. Road infrastructure in lower income countries could be especially exposed to increments in the number of days under extreme temperatures, generating higher investment needs despite having very limited budgets. Meanwhile, extreme rainfall could be the most worrisome factor for the road network in South America, where more than 45% of the road network in many countries is projected to experience very high rises in the maximum accumulated rainfall over five consecutive days.

In the "business as usual" scenario, the sector's emissions will increase significantly. Failing to take decisive actions to decarbonize transportation in LAC would lead to the sector's emissions increasing an estimated 17% by 2050 compared to 2019, far from the levels required to achieve the goal of the Paris Agreement. The transportation of goods would generate the largest increases. In effect, inter-urban road transportation would grow about 23% as a consequence of the rise in economic activity. Similarly, at the urban level, freight transportation would be the largest CO2 emitter, with a 40% increase between 2019 and 2050. Conversely, meeting the goal of the Paris Agreement would require LAC to cut transportation emissions by 47% by 2050 compared to 2019 levels.

The next two years will be key to catalyze the systemic shift. It's time to act. The challenges posed by CC for the survival of humanity require setting the fight against it as an unquestionable public policy pillar in the region. There are four areas of action where LAC countries need to generate a big push that allows them to move forward towards the sector's decarbonization and climate resilience: (i) identifying decarbonization and climate resilience as sector priorities within a vision of efficient, inclusive, and sustainable transportation (ii) developing policy instruments that help achieve these goals; (iii) adapting institutions so they can perform the required actions; and (iv) generating strategic alliances with government agencies as well as private, academic, and civil society sectors. In the short term, the big push requires establishing decarbonization and climate resilience as public policy pillars in transportation and developing a regulatory framework that enables the transition. In the medium term, policies and programs that help scaling up actions must be implemented, and in the long-term, carbon-neutrality and the strengthening of the sector's climate resilience should be achieved (Figure S.9). In the context of a vision of systemic change in transportation, required actions to advance the decarbonization and climate resilience of transportation can also contribute to solve the structural problems that the region faces in terms of equity, road safety and sustainability of the sector. In this sense, LAC must begin to act now and move towards sustainable transportation systems, while benefiting in parallel from the progress made by benchmark countries in terms of mitigation and adaptation of the sector.

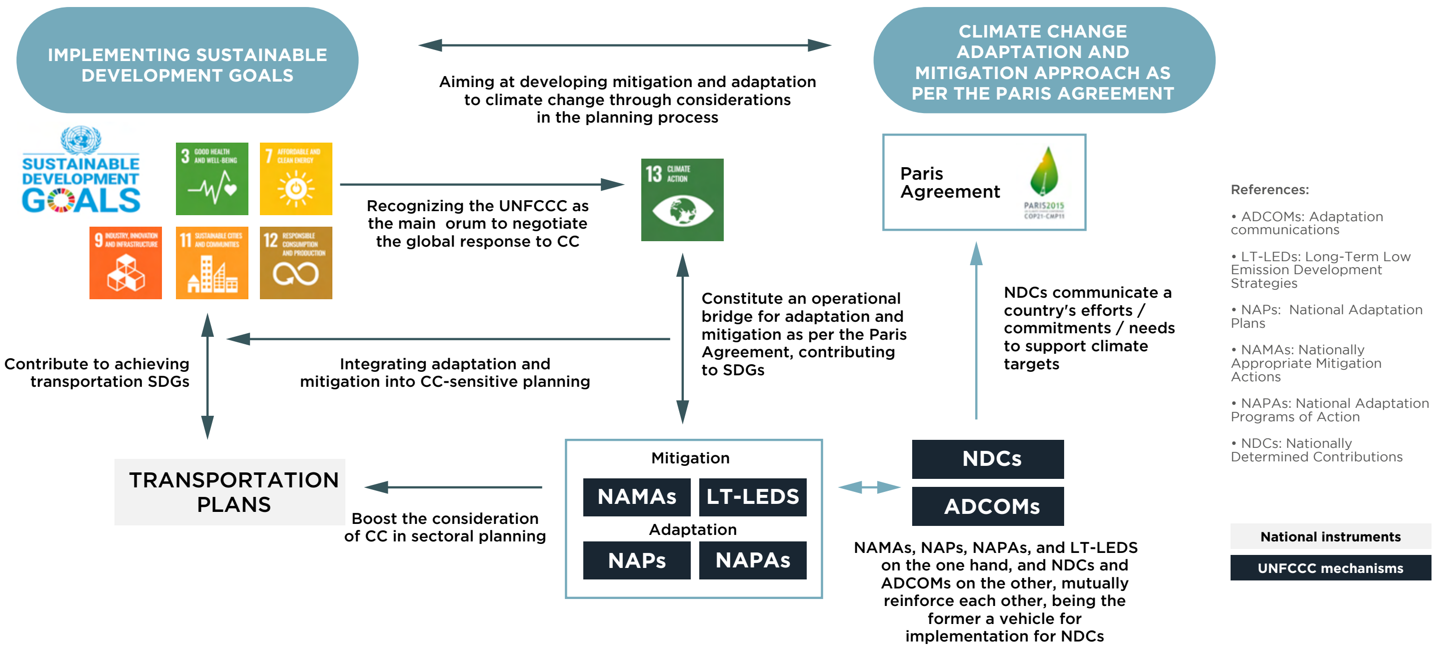
FIGURE S.9. **Definition of main goals related with decarbonization and adaptation of transportation to climate change in the region**



Source: Prepared by the authors.

At the international level, different prioritization and planning mechanisms are available within the UNFCCC (see Chapter 3). Under the Paris Agreement, parties must submit Nationally Determined Contributions (NDCs), which set out the objectives and actions they will take to reduce their greenhouse gas (GHG) emissions. Additionally, the UNFCCC includes different mechanisms for countries to communicate their CC mitigation and adaptation measures and targets, mainly the Long-Term Low-Emission Development Strategies (LT-LEDS), National Adaptation Plans (NAPs), Adaptation Communications (ADCOMs), National Adaptation Action Programs (NAPAs) and Nationally Appropriate Mitigation Actions (NAMAs). These mechanisms are coherent and interrelated (Figure S.10). For example, LT-LEDS modeling exercises provide valuable information on short- and medium-term options and uncertainties that support the NDC formulation process. For their part, NAMAs make it possible to disaggregate national NDC objectives down to the sectoral level, establish monitoring and verification systems, and facilitate the mobilization of financing for the implementation of NDCs. On the other hand, the NAPs present sectoral or territorial priorities and goals in terms of adaptation, and the ADCOMs are used as instruments to report support needs and specific progress to date in the implementation of prioritized actions.

FIGURE S.10. **Interactions between mechanisms established by the UNFCCC**



Source: Prepared by the authors based on NDC Partnership (2023).

Although transportation is mentioned in 19 of the 26 NDCs of LAC countries, only two set emission reduction targets. Regarding the proposed measures, most belong to the "Improve" pillar within the "Avoid-Shift-Improve" model, with special focus on the promotion of electromobility. Freight transport and adaptation to CC are scarcely mentioned in the NDCs, and there is insufficient information and monitoring systems for goal achievement. Likewise, NDC targets are not always integrated into national policies and plans. This absence suggests, on the one hand, that the translation of long-term objectives into actions is not planned or budgeted for in local policy and, on the other, a certain lack of coordination between the agencies involved in the elaboration of the NDC and the agencies with sectoral mandate.

There is heterogeneity in the use of the other mechanisms envisaged by the UNFCCC. Seven LAC countries have LT-LEDS, out of 58 worldwide. Most of the measures regarding transportation fall within the scope of "Shift", promoting the improvement of public transportation and active mobility. As in NDCs, attention to freight transportation and adaptation to CC is very limited. Nine LAC countries have NAPs, out of 45 available worldwide. These highlight the call to generate information and install early warning systems, strengthen inter-institutional collaboration and collaboration with local authorities, carry out awareness campaigns, and promote innovation. However, these NAPs do not clearly identify which agencies or institutions are responsible for the implementation of actions and which are collaborators, what are the compliance indicators, and what are the sources of financing. Only Haiti has a NAPA and it makes no reference to transportation. Finally, in the region there are several NAMAs related to the sector, mainly laying out actions for urban mobility. Given the non-binding nature of these mechanisms, it is key to include them in national planning instruments.

Actions implemented by benchmark countries provide good practices and lessons to generate a coherent policy framework that encourages the decarbonization and climate resilience of transportation in LAC (see Chapter 4). All benchmark countries have a set of plans that place the battle against CC as one of the sector's main challenges. Along with the fight against CC, these plans mention additional objectives such as: (i) positioning as first movers in the transition; (ii) mitigating the economic impacts of the energy transition in key sectors for the economy, such as the automotive, maritime or aviation industries; (iii) attracting investments and generating green jobs that compensate for those that may be lost in the transition; (iv) lead the definition of standards at global level; and (v) improving the quality of life by reducing local emissions and environmental pollution. At the same time, all benchmark countries mention adaptation to CC among the most important challenges of the sector and have sectoral and subsectoral, national and local strategies in this regard.

At the national and local levels, identifying decarbonization and climate resilience as sector priorities requires introducing changes in planning instruments. The main document to adjust is the National Transport Plan or equivalent, which must recognize the importance of these aspects for the future of transportation in all its modes, as well as for the achievement of Paris Agreement goals and the promotion of an environmentally friendly development model. The Plan should set out the vision on top of which specific plans and instruments can be generated for each mode of transportation or subsector. This should be done by the authority in charge of the sector, in coordination with the environmental and energy authorities. Coordination is essential given the interconnection between transportation decarbonization and energy transformation. Likewise, priorities must be consistent with the goals established in each country's NDC. The priorities to be identified in the Plan can be summarized as shown in Figure S.11.

FIGURE S.11. **Strategic priorities in planning the transportation sector's decarbonization and adaptation to CC**

Promoting sustainable mobility

- Support the transition to zero-emission vehicles ("improve" pillar)
- Encourage measures to reduce trips and shift to more sustainable modes, both for passengers and freight
- Strengthen road safety
- Promote the inclusion of vulnerable populations
- Close the gap between large, medium and small cities, providing quality mobility for citizens

Reducing the global carbon footprint of transportation

- Consider the full life cycle assessment of projects
- Encourage inter- and multi-modality for passengers and freight
- Consider international and local measures for the aviation and maritime sectors
- Link transportation to the energy transition and its impact on the national economy
- Use nature-based solutions to enhance the transportation sector's adaptation to climate change and mitigation of its impacts

Strengthening the resilience of systems

- Generate information and early warning systems
- Develop scenarios and adopt methodologies of decision making under deep uncertainty
- Combine soft actions (regulatory framework) and hard actions (infrastructure investments)

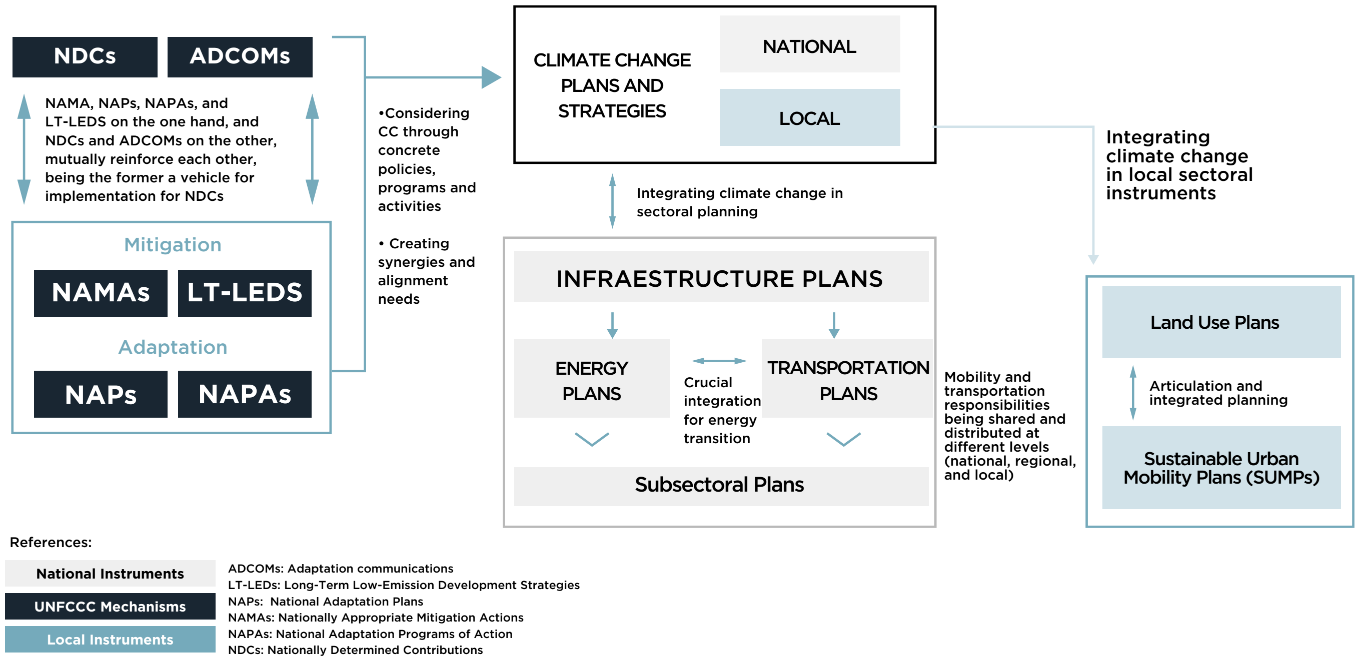
Investing in innovation & technology

- Encourage R&D in technologies for sustainability and climate resilience
- Promote pilots and regulatory sandboxes for testing technologies
- Establish partnerships with the private sector, academia, and international cooperation to capitalize on quick-wins

Source: Prepared by the authors.

Given CC's cross-cutting nature, it is important to define the role of government agencies in the implementation of the Plan. In general, the Ministries of Environment establish guidelines on the goals to be achieved in the fight against CC. According to these guidelines, the Ministries of Transportation identify the objectives and actions for the sector, while the Ministries of Energy do the same on the energy transition. Given the interdependence of measures in the three sectors, it is essential to establish coordination mechanisms among them and to identify common goals and progress monitoring mechanisms, in addition to coordination with territorial planning (Figure S.12).

FIGURE S.12. **Articulation of NDCs with national, local, and sectoral CC instruments**

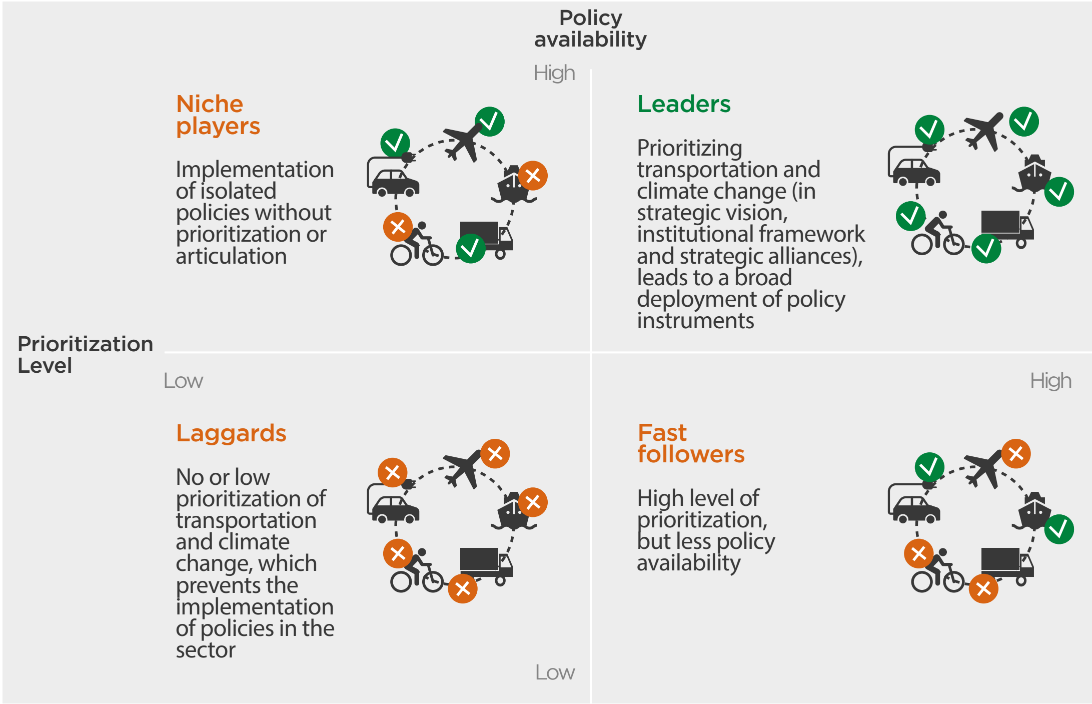


Source: Prepared by the authors.

Benchmark countries' sectoral and subsectoral plans lay out a variety of instruments to incentivize transportation decarbonization and resilience. These are classified into five groups: (i) regulations that limit the emission of pollutants and foster CC adaptation; (ii) procurement processes that include environmental criteria; (iii) pricing instruments; (iv) non-financial incentives; and (v) public sector investments. For their design and implementation, they have strengthened their agencies, with specialized units and information and technology systems to monitor trends and evaluate policy effectiveness. At the same time, they establish vertical coordination mechanisms between different levels of government, leveraging each level's powers. Lastly, they generate strategic alliances with the private sector, academia, and civil society to advance in the decarbonization and CC adaptation of transportation, starting with the integration of these stakeholders in the design of national and subsectoral plans through prior consultations and working groups with the public sector, and using tools such as pilots and agreements to promote innovation and technological development.

LAC countries have different starting points in the construction of a policy framework that promotes the decarbonization and climate resilience of transportation (see Chapter 5). Two dimensions that allow us to visualize heterogeneity in the region can be identified: (i) the level of prioritization of CC mitigation and adaptation policies (at national, regional, and local levels); and (ii) the availability of these policies, giving rise to four different groups of countries (Figure S.13). The first group comprises “laggard” countries, which have not prioritized decarbonization or the adaptation of transportation to CC in their strategic vision for the sector, and have made no progress towards policy implementation in this area. The second group of countries corresponds to “niche players”, who have successfully advanced in the implementation of certain policies, but in isolation, without identifying CC as a priority for the transportation sector or having articulated policies. The third group of countries are the “fast followers”, which have prioritized mitigation and/or adaptation to CC in their vision and strategies for the sector, but are lagging behind in the implementation of a comprehensive policy framework. Finally, there are the “leaders”, who have identified CC as a pillar for public policies in the sector, have a set of actions to materialize them, have strengthened their institutions, and have developed strategic alliances for the success of these policies. In this way, the identification of the initial situation by each country in terms of progress in prioritization and availability of CC mitigation and adaptation policies makes it possible to adjust the actions to be taken according to the particular characteristics of the local reality, by identifying the areas of action that require development and strengthening.

FIGURE S.13. **Key aspects for the definition of a roadmap: Classifying countries according to level of prioritization and availability of transportation and CC policies**



Source: Prepared by the authors.

Note: A high level of CC prioritization in the transport sector implies the development of action areas associated with the strategic vision, institutional framework, and strategic alliances. Meanwhile, a high level of policy availability implies wide deployment of the action area related with policy instruments.

Heterogeneity between countries is also evident in the transportation subsectors. There are cities in the region that are world leaders in electrification of the urban transportation fleet. There are also countries that are conducting pilots to decarbonize maritime transportation. Others are focusing on increasing the climate resilience of their road networks. Thus, for example, a country may be classified as a “niche player” in a certain subsector, while it may be a “fast follower” in another. There may also be different realities within the same country, as is the case with the electrification of public transportation. Finally, the state of technological and regulatory progress in decarbonization and adaptation is very different in each subsector. For this reason, this document not only analyzes the sector at a general level, but also proposes roadmaps for the most important subsectors in the region: urban mobility, road transportation, maritime transportation and air transportation. The roadmaps are based on an international benchmark for each subsector, adapting the proposals to the reality of LAC.

It is important to recognize that, because it is comprised of developing countries, the region has fiscal, financial, economic, and social constraints to undertake an aggressive investment program that modifies the current development model. Consequently, the transition must be gradual and fair, always aiming at reaching carbon neutrality. International cooperation concerning technology transfer and best practices, as well as the provision of climate funding, will be key to accelerate the shift from the categories of "laggards", "niche players", and "fast followers" towards the implementation of the policies required for transportation decarbonization and climate resilience and, in general, for low-carbon development, especially for lower-income LAC countries. The transition must also ensure that no one is left behind at the national level, which requires including and considering targeted actions for stakeholders facing the greatest constraints within each subsector.

The joint development and implementation of a battery of funding and financing mechanisms can help ensure that the sector has the required resources to develop efficient, inclusive, and sustainable transportation systems. To close existing gaps, the transportation sector must become more efficient in the use of funds and employed instruments, while also exploring innovative funding and financing mechanisms. First, it is imperative to boost the efficient use of currently available funds, i.e. to maximize the return of each investment through the effective management and careful execution of each project. Secondly, it is necessary to look for alternatives to increase funding for transportation infrastructure through mechanisms already in use, such as the elimination of fossil fuel subsidies, replacing general subsidies with subsidies focused on interest groups, or allowing the adjustment of public transportation fares. Thirdly, innovative funding mechanisms that are still seldom used in the region should be explored, such as value capture mechanisms, which help recover part of the surplus generated by infrastructure (and help financing system improvements through land use planning that encourages development in transit-connected areas), new business models for electric public transportation (such as separating bus ownership from bus operation), or climate funds, which allocate resources for projects that contribute to CC mitigation and adaptation, including concessional loans and equity contributions. Finally, innovative forms of funding, such as structured financial incentives and scaling through coalitions of sponsors, can help attract private sector investment, in addition to promoting CC-sensitive public-private partnerships in the sector.

Despite these difficulties, the transformation of transportation to fight against CC is a task that must begin without delay in LAC. The time to act and reverse the effects of CC is running out. By 2030, and in the context of a just transition, LAC countries must generate the required enabling frameworks and investments to move towards net-zero transportation systems by 2050 and meet the goals of an international regulatory framework that will become increasingly restrictive around the use of fossil fuels. At the same time, LAC countries, especially those in the Caribbean and Central America, will be severely affected by CC, which urgently increases the need to foster the resilience of the transportation sector in the region. Vulnerable populations, with more precarious settlements and travel patterns, will be particularly affected by increased exposure to transportation infrastructure disruptions.

Lastly, the climate crisis offers an opportunity for the region: promoting a systemic transformation of transportation can generate new income sources for the region in the form of renewable energy production for transportation, strategic positioning in the reconfiguration of global transport networks, generation of green jobs within the framework of industrial reconversion, and attraction of international investments and funds to catalyze the changes required by the sector in the fight against CC.

Introduction

It is time to take action. The challenges posed by Climate Change (CC) for the survival of humanity require setting the fight against it as an unquestionable pillar of public policy. Analyses by the scientific community indicate that countries have less than a decade to radically cut their emissions in order to avoid irreversible damage to our planet. For the transportation sector, one of the largest emitters of Greenhouse Gases (GHG) worldwide, the challenge is enormous. It not only requires changing energy sources, but also a systemic restructuring that has not been seen throughout the sector's history. In addition, this change must be well under way by 2030, practically in little more than five years.

Through the Paris Agreement, Latin American and Caribbean (LAC) countries have committed to reduce their emissions by 2030. Now is the time to implement actions to fulfill this commitment. Overall, however, the region is still a long way from the public policy developments seen in other geographies. This applies to all modes of transportation: land, air, maritime, and urban mobility. Lack of prioritization, limited resources, distance from technological development hubs, and certain characteristics of transportation systems in the region are some of the challenges that hinder the sector's progress towards greater sustainability.

This gap is also reflected in how well-prepared infrastructure and services are for the extreme weather events brought about by global warming. Despite being one of the regions with the highest number of countries exposed to CC, actions to improve climate resilience of roads, ports, airports, and public transportation systems are still limited. As a result, countries are already experiencing severe disruptions, with road closures preventing access to markets and health centers, ports disrupting international trade, and airports affecting the tourism industry, one of the most important sectors for the region.

Adding to the big push of public policies that is required to bring LAC into a path of decisive actions for CC mitigation and adaptation, in 2021 the Inter-American Development Bank (IDB) committed to align all its financing operations with the objectives of the Paris Agreement. Furthermore, IDB is a key partner for policy development in this topic, providing technical assistance, facilitating knowledge exchange, and promoting collective action in the region.

In this context, this report analyses the status of transportation as an active and passive subject of CC, identifies gaps with respect to countries that are at the forefront of the transformation of the sector at global level, and proposes policy recommendations based both on these countries' best practices and on the concept of just transition. In this way, the study presents an institutional and policy architecture applied to transportation to accelerate the pace of systemic change required by the sector and allow meeting international goals.

To this end, during 2022 and 2023, more than 250 policy, private sector, and academic documents were reviewed; statistical analyses were performed using big data techniques; and working groups were held with relevant actors at global and regional levels for the different transportation modes in order to validate the results of the analyses and recommendations. The study was carried out in collaboration with the International Transport Forum (ITF) of the Organization for Economic Co-operation and Development (OECD), the International Association of Public Transport (UITP), the International Association of Port Harbors (IAPH), the International Road Federation (IRF), and Airports Council International – Latin America & the Caribbean (ACI-LAC).

The study's results are presented as follows: Chapter 1 contains a diagnosis of transportation and CC in LAC; Chapter 2 presents the scenarios that the sector could face if urgent actions are not taken; Chapter 3 analyzes the international commitments made by LAC countries in the fight against climate change; Chapter 4 presents the best practices of a group of benchmark countries in terms of public policies to promote mitigation and adaptation to CC in the transportation sector; and Chapter 5 contains roadmaps with short, medium, and long-term recommendations to make a big push in the green transformation of LAC's transportation sector, based on the good practices of benchmark countries and on the concept of just transition.

1.

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1. Transportation as an active and passive subject of climate change in LAC

If LAC invests 1.4% of its GDP annually until 2030, it will be able to close its infrastructure transportation gap and make progress in meeting SDGs.

The transportation sector plays a key role in socio-economic development by allowing the movement of people and goods. Transportation directly and indirectly impacts socioeconomic development through different channels, ranging from logistics costs faced by firms when shipping their goods, to the effect on quality of life for public transportation users with access to efficient and high-quality services. Transportation influences 76 targets of the Sustainable Development Goals (SDGs), spread across 17 SDGs (45%) (UNOPS et al., 2021). In particular, it is a catalyst to improve social inclusion and equity in the region, allowing access to work, health, and education opportunities for vulnerable populations, thus contributing to breaking the cycle of poverty and inequality (Scholl et al., 2022). For its part, investment in infrastructure, with its positive effects on employment, accessibility, and economic development, is critical to achieving SDGs. It has been estimated that if LAC were to invest 1.4% of its Gross Domestic Product (GDP) annually until 2030, the region could close road, airport, and public transportation infrastructure gaps, advancing in the fulfillment of these objectives (Brichen et al., 2021).

Transportation plays a dual role in CC, both as an active and a passive subject. On one hand, the transportation sector is a source of GHG emissions, responsible for CC. Although LAC's share of total GHG emissions worldwide is small, as are transportation emissions per capita when compared to those of developed countries, these emissions have been growing. In addition, emissions in the sector generate significant negative impacts on health by worsening air quality. On the other hand, the transportation sector is highly vulnerable to the effects of CC. The increase in the intensity and frequency of extreme weather events generates damages to transportation infrastructure and service interruptions, which translate into greater economic costs for societies.

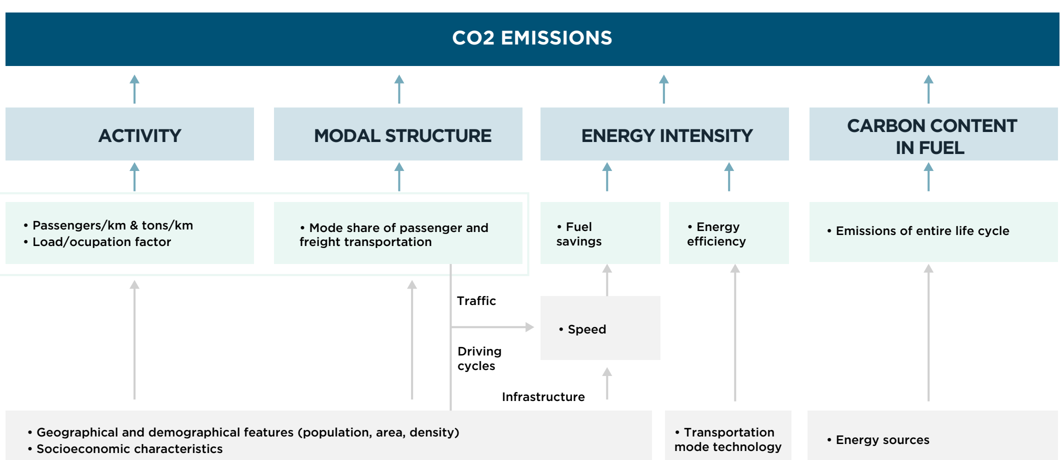
This chapter provides a diagnosis of the relationship between transportation and CC in LAC, starting with the magnitude and contextualization of emissions in the region and their contribution to CC and worsening air quality. It then addresses the impacts of extreme weather events on transportation infrastructure and services. This information will serve as a basis to understand historical trends and current status in LAC compared to other regions, as well as intra-regional differences and particularities present at the local level. Chapter 2 will present future trends if the region does not take actions to reverse current projections.

1.1.
Contribution of transportation to GHG emissions

Transportation is key to reduce GHG emissions and fight against CC. CC results from increased concentrations of GHGs, which act as a blanket that wraps the Earth, causing it to retain more heat and producing long-term changes in the temperature of the planet. Carbon dioxide (CO2) is the predominant gas among these emissions, and its main origin is the use of fossil fuels for energy production. In general terms, emissions from the transportation sector depend on activity level (A), modal structure (S), energy intensity (I), and carbon content of the fuel (F), an approach known as ASIF (Figure 1.1). With 25% of global emissions, transportation is the second largest contributor of CO2 from fuel combustion, behind electricity generation and heating (Figure 1.2.a). At the same time, the volume of emissions from the sector has increased significantly in recent decades, from 4.6 Gigatonnes of carbon dioxide (GtCO2) in 1990 to 8.3 GtCO2 in 2019[1] (Figure 1.2.b).

FIGURE 1.1.

Parameters affecting transportation emissions



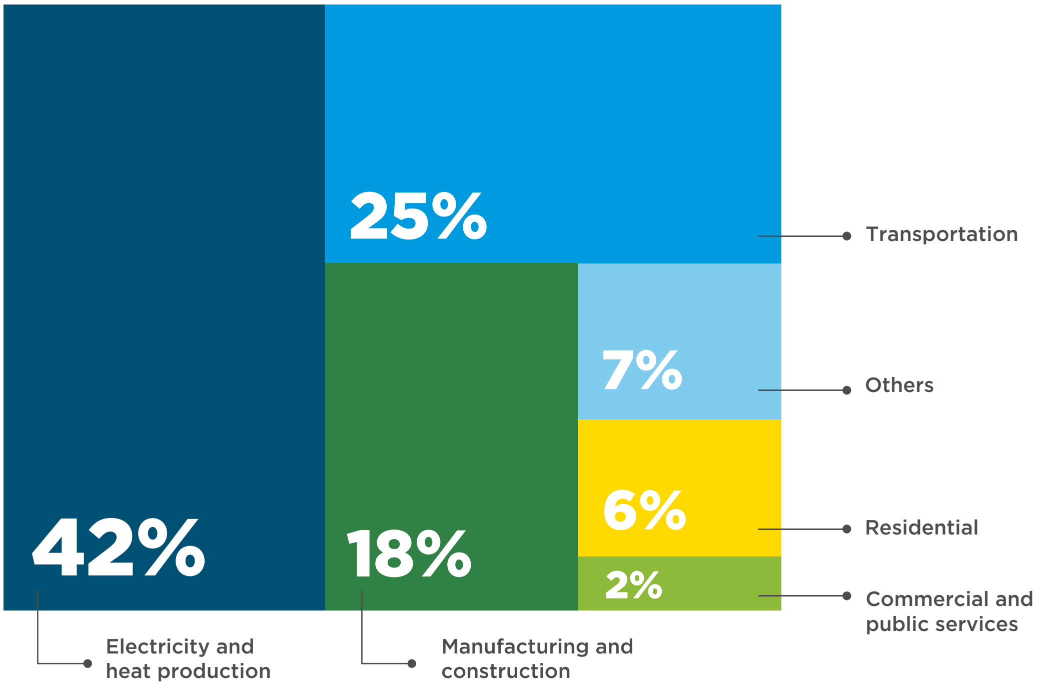
Source: Prepared by the authors based on Kii (2020) and Schipper et al. (2007).

[1] In line with international studies, the year 2019 is taken as a reference to avoid distortions in the analysis caused by the COVID- 19 pandemic.

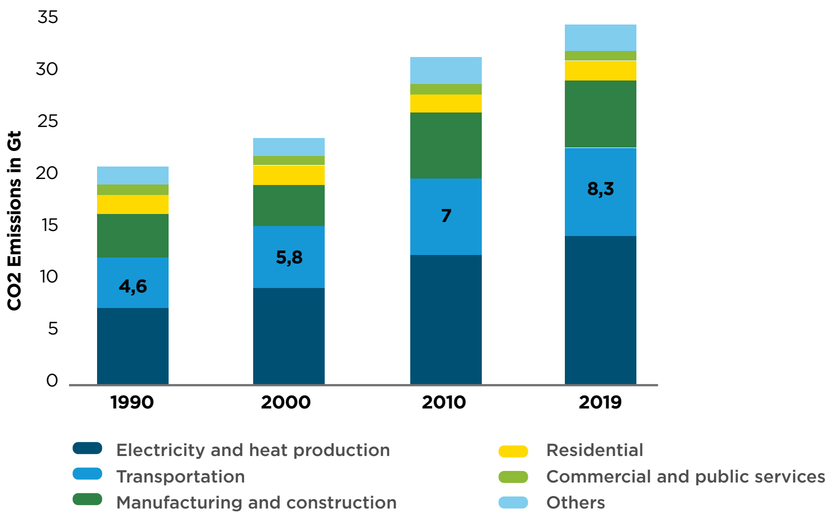
FIGURE 1.2.

Global CO2 emissions from fuel combustion by sector in 1990, 2000, 2010, and 2019

1.2.a
Share (2019)



1.2.b
Total emissions (1990-2019)



Source: Prepared by the authors based on data from IEA (2022f).

Note: Emissions from the transportation sector include those proceeding from maritime and aviation bunkers (fuel consumed by international transportation).

In addition to its role in the fight against CC, the transportation sector is critical to reduce air pollution. Although often addressed separately, air pollution and CC are two sides of the same coin. Both are mostly caused by the same sources and can have similar solutions, so it is important to address them together with a special focus on people's health. Indeed, many of the sources of outdoor air pollution are also significant sources of CO2 emissions. In the case of transportation, air pollutants and GHGs share the same source, corresponding to emissions from internal combustion vehicles. As will be seen further below, while countries in the region are not responsible for the majority of global GHG emissions, they will benefit greatly from cutting fossil fuel consumption and switching to cleaner fuels, as it will allow them to reduce not only such emissions but also air pollution, with a consequent positive impact on health (Box 1.1).

BOX 1.1.

Transportation, air pollution, and impact on health

Transportation emissions have a negative effect on air quality and public health. Vehicles with internal combustion engines using petroleum-based fuels such as gasoline and diesel emit Carbon Monoxide (CO), Nitrogen Oxides (NOx), Non-Methane Hydrocarbons (HC), sulfur oxides, airborne toxins, and Particulate Matter (PM). PM2.5 is among the most harmful vehicular emissions, originating from engine exhaust systems as a result of hydrocarbon condensation. A major component of PM2.5 is Black Carbon or soot (BC), which absorbs toxic substances such as organic compounds and heavy metals. Ozone is a secondary pollutant that also has negative health impacts. Vehicles do not emit ozone directly, but it is formed in the atmosphere from pollutant precursors such as CO, HC and NOx. Exposure to these pollutants is associated with a variety of harmful health effects and chronic diseases, some of which can lead to premature death. For example, in 2017, an estimated 2.9 million premature deaths globally from ischemic heart disease, stroke, Chronic Obstructive Pulmonary Disease (COPD), lung cancer, lower respiratory tract infections, and

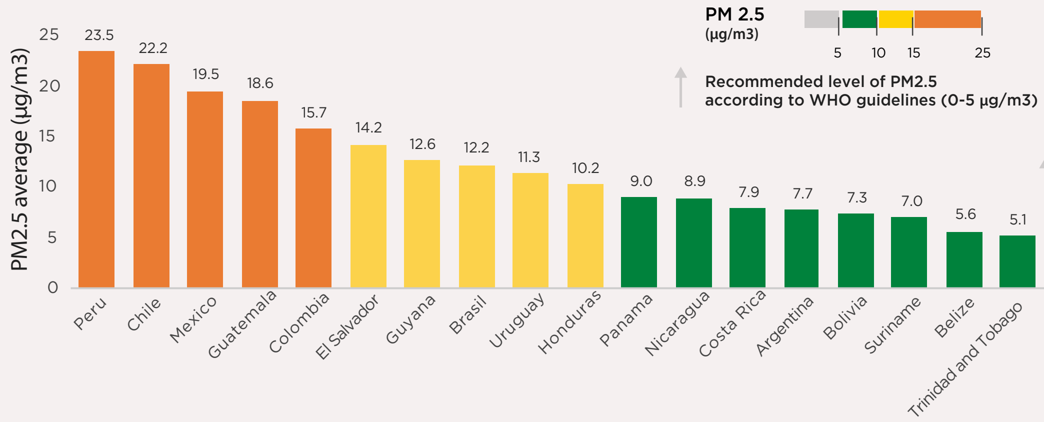
In 2022, none of the LAC countries with available data met the WHO annual PM2.5 guidance.

type II diabetes mellitus were associated with PM2.5 emissions and nearly 500,000 with tropospheric ozone (Stanaway et al., 2018). Within the transportation sector, diesel and gasoline vehicles have the greatest impact on PM2.5 emissions (Stanaway et al., 2018). In LAC, premature deaths attributable to air pollution (indoor and outdoor) range from 20 to 60 deaths per 100,000 inhabitants (IHME, 2019). In particular, deaths from air pollution from fossil fuels are estimated at nearly 69,000 (Lelieveld et al., 2019). The cost of lost well-being due to premature deaths associated with particulate matter is equivalent to 3.4% of regional GDP (World Bank, 2019a).

In the region, more than 150 million people live in cities where air quality is below World Health Organization (WHO) guidelines, with air pollution representing the main environmental risk to public health (PAHO, 2023). In 2022, none of the 18 LAC countries with available data met the WHO annual guideline of PM2.5 between 0 and 5.0 µg/m3 (Figure 1.1.1), according to the IQAir air quality ranking (IQAir, 2022). However, it is important to consider that national averages hide the heterogeneity between cities in the sample. In the case of Argentina, for example, of the six cities with available measurements for 2022, two cities were found to exceed the WHO-established level between 2 and 3 times (range between 10 and 15 µg/m3), while the four other cities exceeded the value between 1 and 2 times (range between 5 and 10 µg/m3). At the urban level, only 9.7% of cities in the region met the WHO guideline of 5 µg/m3. Cities with the most critical PM2.5 concentration (between 35 and 50 µg/m3) are located in Peru (San Juan de Lurigancho, Vitarte, Santa Anita, and Caraballo), Chile (Quilpué and Coyhaique), and Mexico (Metepec). The problem of air pollution is accentuated in the most urbanized cities with transportation systems based on private mobility, and in those where geographical and climatic conditions favor the concentration of polluted air masses.

FIGURE 1.1.1

Air quality ranking in LAC countries (2022)



Source: Prepared by the authors based on IQAir (2022).

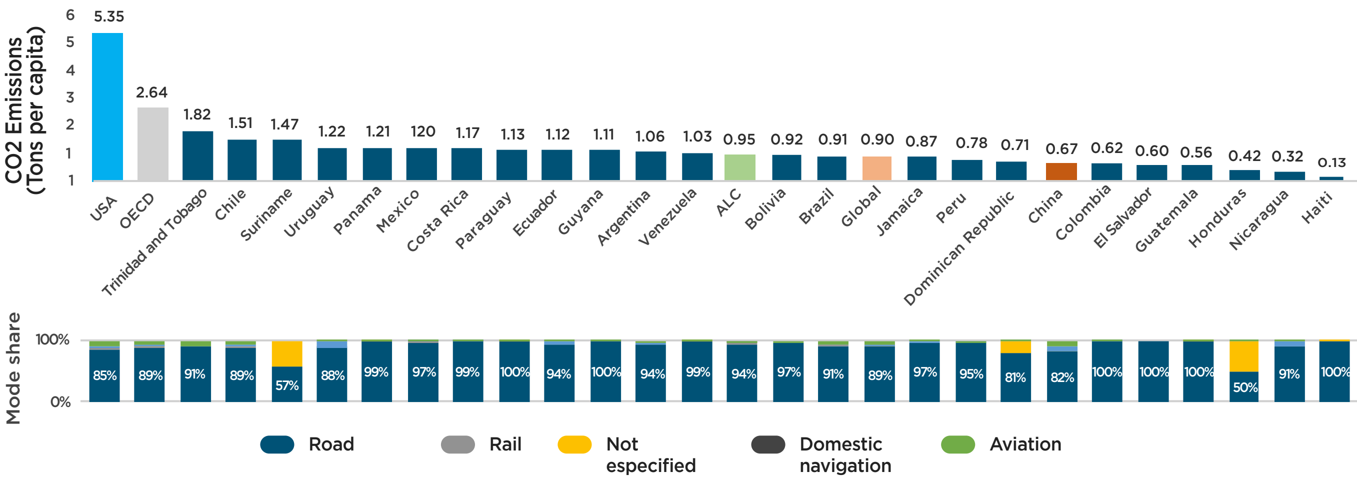
Note: PM2.5 level recommended by WHO guidelines as of September 2021: 0 – 5.0 µg/m3.

The problem of air pollution particularly affects children in the region. In LAC, 105 million children are exposed to air pollution (UNICEF, 2023). Children are especially vulnerable to air pollution because their lungs and immune systems are developing, and their airways are smaller, making infections more likely to cause blockages (UNICEF, 2021). Impacts of traffic-driven air pollution in the region are diverse. In Mexico City (Mexico), Santiago de Chile (Chile), and Sao Paulo and Rio de Janeiro (Brazil), there is an increased risk of death from respiratory diseases in infants and children aged 1 to 5 years (Gouveia et al., 2018). In Sao Paulo, babies of women in regions with higher levels of traffic-related pollution were found to have an almost 50% higher risk of early neonatal death, compared to those living in areas of lower pollution (de Medeiros et al., 2009). Likewise, in Mexico, exposure to traffic-related pollution has also been associated with increased asthma, more severe asthma symptoms, and lower lung function in children (Barraza-Villarreal et al., 2011; Romieu et al., 2003).

LAC accounts for a small share of total CO2 emissions from the transportation sector worldwide, with 9% of global transportation emissions (2% when considering global emissions from all sectors), compared to 32% for Asia Pacific and 28% for North America. Per capita, LAC's average CO2 emissions stood at 0.95 tonnes in 2019, above China and slightly above the global average (0.9 tonnes per capita), but well below the OECD and US averages, which reached values of 2.6 and 5.4 tonnes per capita, respectively (Figure 1.3). Also, the transportation sector is the largest source of GHG emissions in the region, accounting for 40% of total emissions.

FIGURE 1.3.

CO2 emissions from fuel combustion from the transportation sector and mode share for LAC countries and by region (2019)



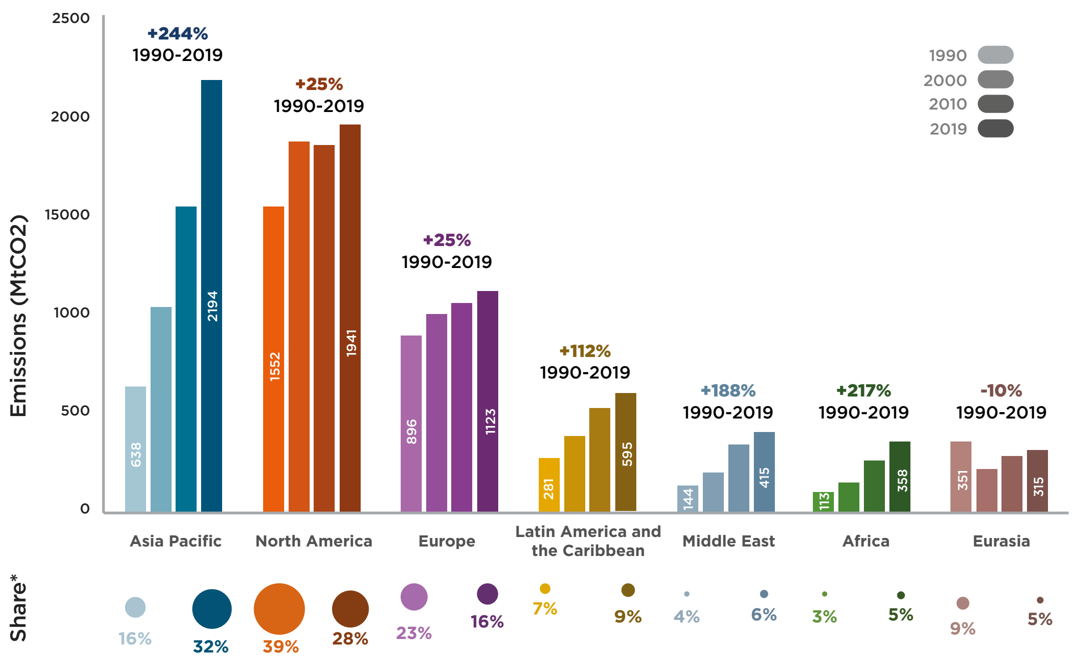
Source: Prepared by the authors based on data from World Bank (2023b) and IEA (2022g, 2022e, 2022f).

Note: Emissions from maritime and aviation bunkers are not included as they cannot be allocated at national or regional level. Does not include pipeline transportation.

In line with global trends, transportation emissions have been on the rise in the region, reaching values of 595 million tonnes of carbon dioxide (MtCO2) in 2019, compared to 281 MtCO2 in 1990 (Figure 1.4). Likewise, the region's share of the global total went from 7% to 9% between 1990 and 2019, while North America and Europe showed significant decreases (-11 and -7 percentage points, respectively). However, it should be noted that LAC is far from the levels of growth verified in Asia Pacific, a region that doubled its global participation in three decades.

FIGURE 1.4.

Historical emissions from the transportation sector by region (1990-2019)

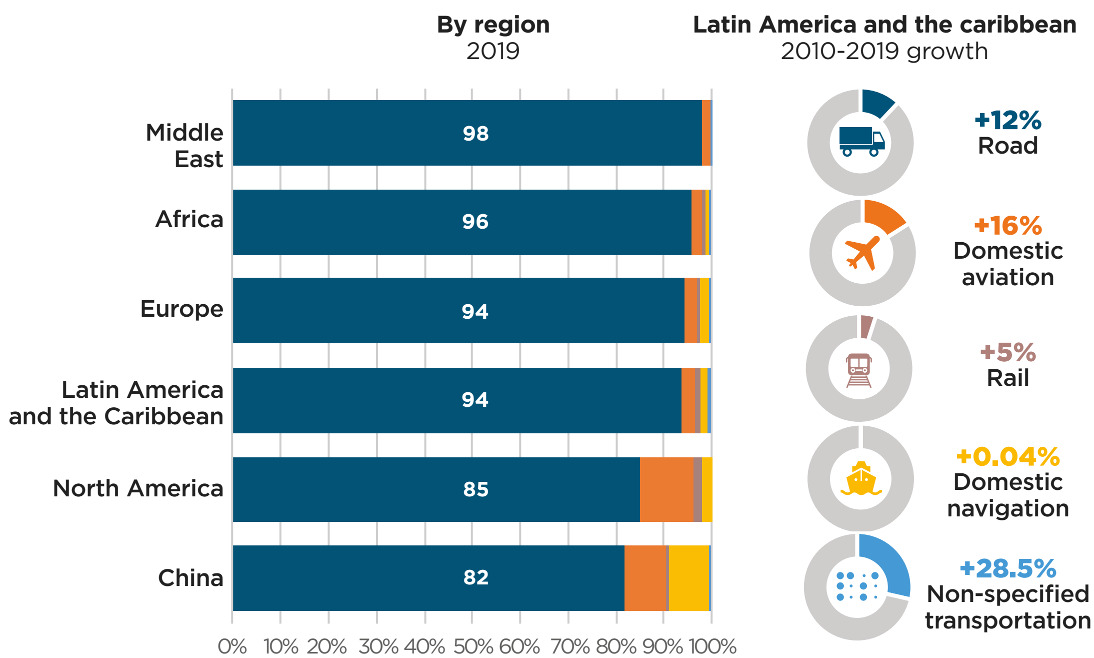


Source: Prepared by the authors based on data from IEA (2022g, 2022e, 2022f).

Note: Data in millions of tons of CO2 – MtCO2. Emissions from maritime and aviation bunkers are not included as they cannot be allocated at national or regional level (1.3 GtCO2 of the total 8.3 GtCO2 of global emissions from the transportation sector in 2019). The classification of countries in regions was made according to IEA (2023c) except for Mexico, which was classified in LAC (in this graph, North America only includes Canada and the United States).

Road transportation is the main contributor of CO2 emissions within LAC's transportation sector, accounting for 92% of the total. This is similar to global values, which range from 82% in China to 98% in the Middle East (Figure 1.5). Domestic aviation contributes with 4%, domestic shipping with 2%, and rail transportation with 1%. Between 2010 and 2019, emissions from domestic aviation grew the most, with a variation of 16% compared to 12% for road transportation and 5% for rail transportation. While aviation emissions increased worldwide, road emissions rose much more sharply in developing countries.

FIGURE 1.5. **Distribution of CO2 emissions by transportation mode for each region and evolution by transportation mode for LAC**



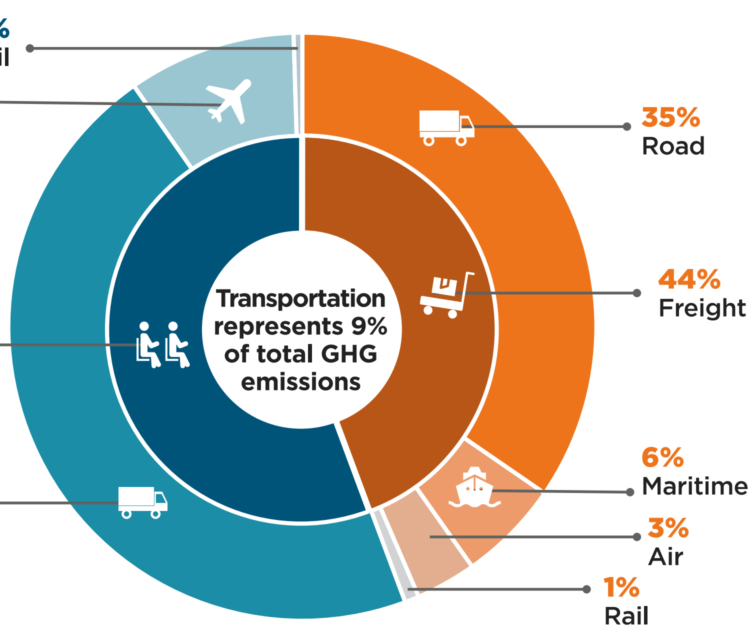
Source: Prepared by the authors based on data from IEA (2022g, 2022e, 2022f).

Note: The analysis by regions does not include emissions from maritime and aviation bunkers, or pipeline transportation.

When differentiating between passengers and freight, most emissions are concentrated in the former. In LAC, 56% of the CO2 produced by the sector comes from passenger transport, mainly from road transportation, followed by air transportation. Regarding freight emissions, road transportation also accounts for virtually all emissions (Figure 1.6). Considering road transportation emissions exclusively, private cars and motorcycles account for 48%, freight transportation contributes with 43%, and the bus fleet is responsible for 9%.

FIGURE 1.6

Emissions by transportation mode in LAC (2019)



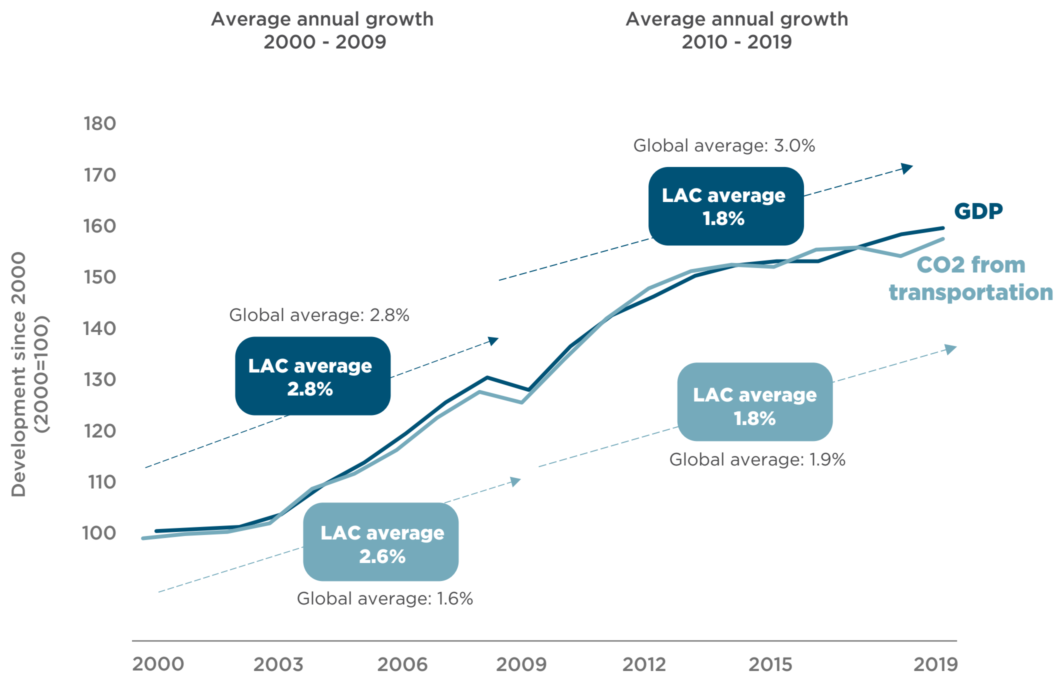
Source: Prepared by the authors based on data projected by ITF (2023a).

Note: Percentages in the figure refer to Tank-to-wheel emissions. Air freight transportation does not include cargo on passenger flights.

In 2019, road freight and passenger transportation accounted for 81% of the sector's emissions in LAC.

Contrasting the observed trend in some advanced countries, data from the region shows that economic growth and CO2 emissions from transportation are coupled. Over the 2000-2009 period, average annual GDP growth in LAC was 2.8%, while transportation emissions increased by 2.6%. Similarly, in the 2010-2019 period there was an average increase of 1.8% in both GDP and transportation emissions (Figure 1.7). Road transportation was the main generator of these emissions. Conversely, most developed countries have managed to decouple emissions and growth. Of 145 analyzed countries, 78 have achieved such decoupling and 12 have seen a decrease in transportation emissions (Foster et al., 2021). While nearly 72% of high-income countries have reached full or relative decoupling, only 29% of low- and middle-income countries have achieved some level of decoupling. In LAC, those that have achieved relative decoupling are Chile, Panama, Argentina, Colombia, Dominican Republic, Mexico, Peru, and Trinidad and Tobago. However, it is worth noting that the decoupling analysis does not take into account the significant role of international trade, whose emissions are not assigned to any country, regardless of whether it is a producer or a consumer country.

FIGURE 1.7. **Coupling between CO2 emissions from transportation and GDP in LAC (2000-2019)**



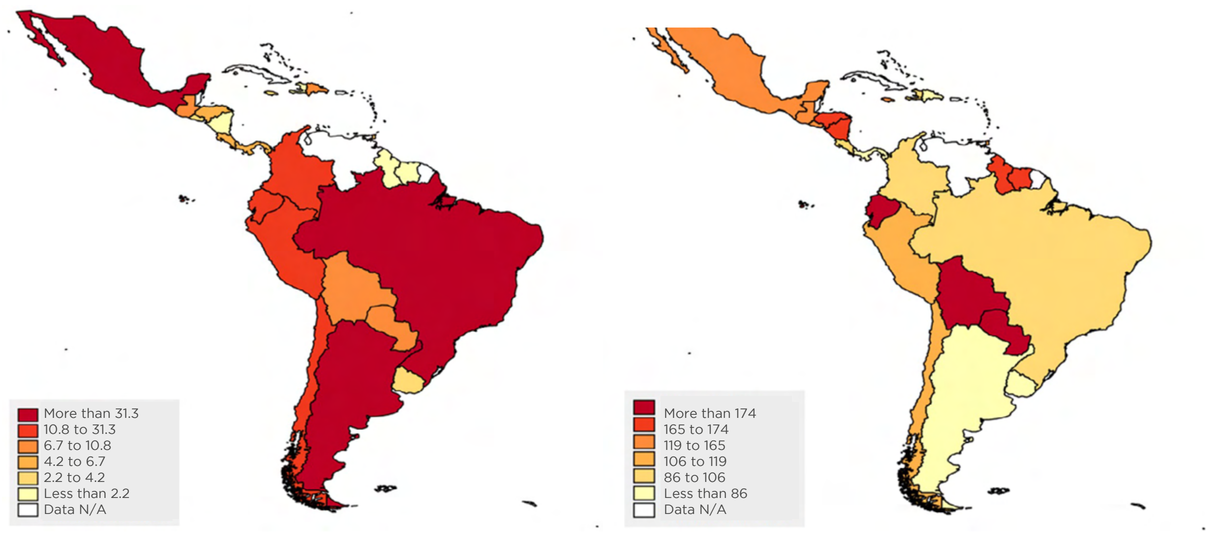
Source: Prepared by the authors based on SLOCAT (2021b), IEA (2022g), and World Bank (2023a).

Note: Analyzed LAC countries are: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, and Uruguay. Venezuela is not included due to the lack of availability of GDP data in this period. Global averages consider all countries, including LAC.

It is interesting to note that the size of the economy is not directly associated with the sector's emissions intensity. Although the countries with the highest volume of emissions are Brazil, Mexico, and Argentina (Figure 1.8.a) –i.e., the region's largest economies–, after adjusting transportation CO2 emissions for GDP, it becomes clear that smaller economies such as Bolivia, Ecuador, Paraguay, and Guyana are the most emissions intensive (Figure 1.8.b). Likewise, most countries in the region have experienced positive growth in GDP-adjusted CO2 emissions in the period 2010-2019, led by Jamaica, Paraguay, and Ecuador (Figure 1.9).

FIGURE 1.8. **Transportation sector's CO2 emissions from fuel combustion (LAC, 2019)**

a. Emissions (MtCO2) **b. GDP-adjusted emissions (grCO2/USD)**

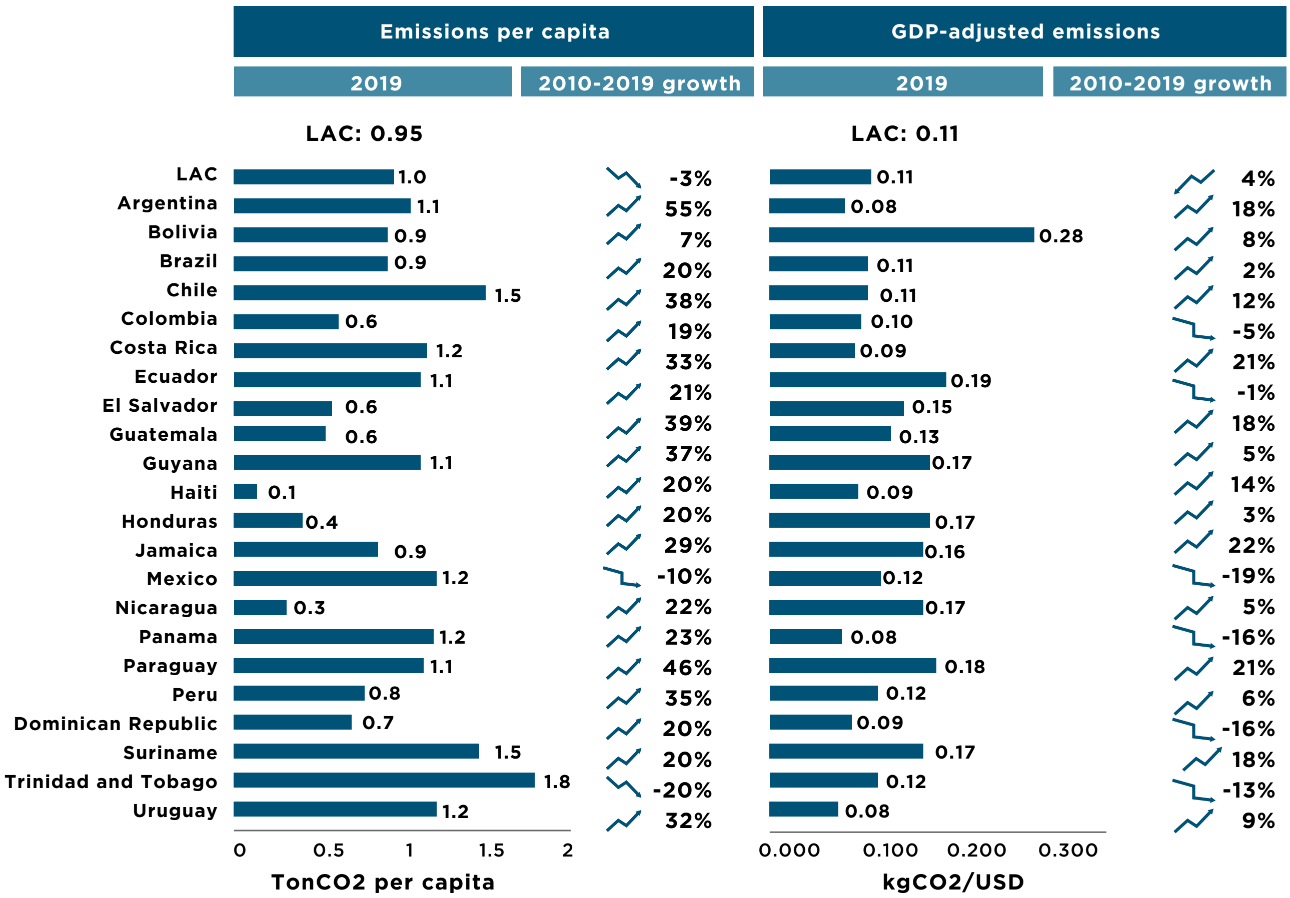


Source: Prepared by the authors based on IEA (2022g) and World Bank (2023a).

Note: GDP is expressed in USD at 2010 constant prices.

In sum, countries in the region have different emission profiles. An analysis of CO2 emissions in per capita terms, GDP-adjusted emissions, and their respective growth in the period 2010-2019 (Figure 1.9) shows significant heterogeneity correlating to each country's socioeconomic and transportation sector characteristics. Most countries show a positive growth trend in both per capita and GDP-adjusted emissions. The following section explores the main factors behind transportation emission trends in the region.

FIGURE 1.9. Transportation sector's CO_2 emissions in LAC (by country)



Source: Prepared by the authors based on data from the World Bank (2023a, 2023b) and IEA (2022g, 2022e, 2022f).

1.2.
Determinants of transportation emission trends in LAC

1.2.1 SOCIOECONOMIC FACTORS

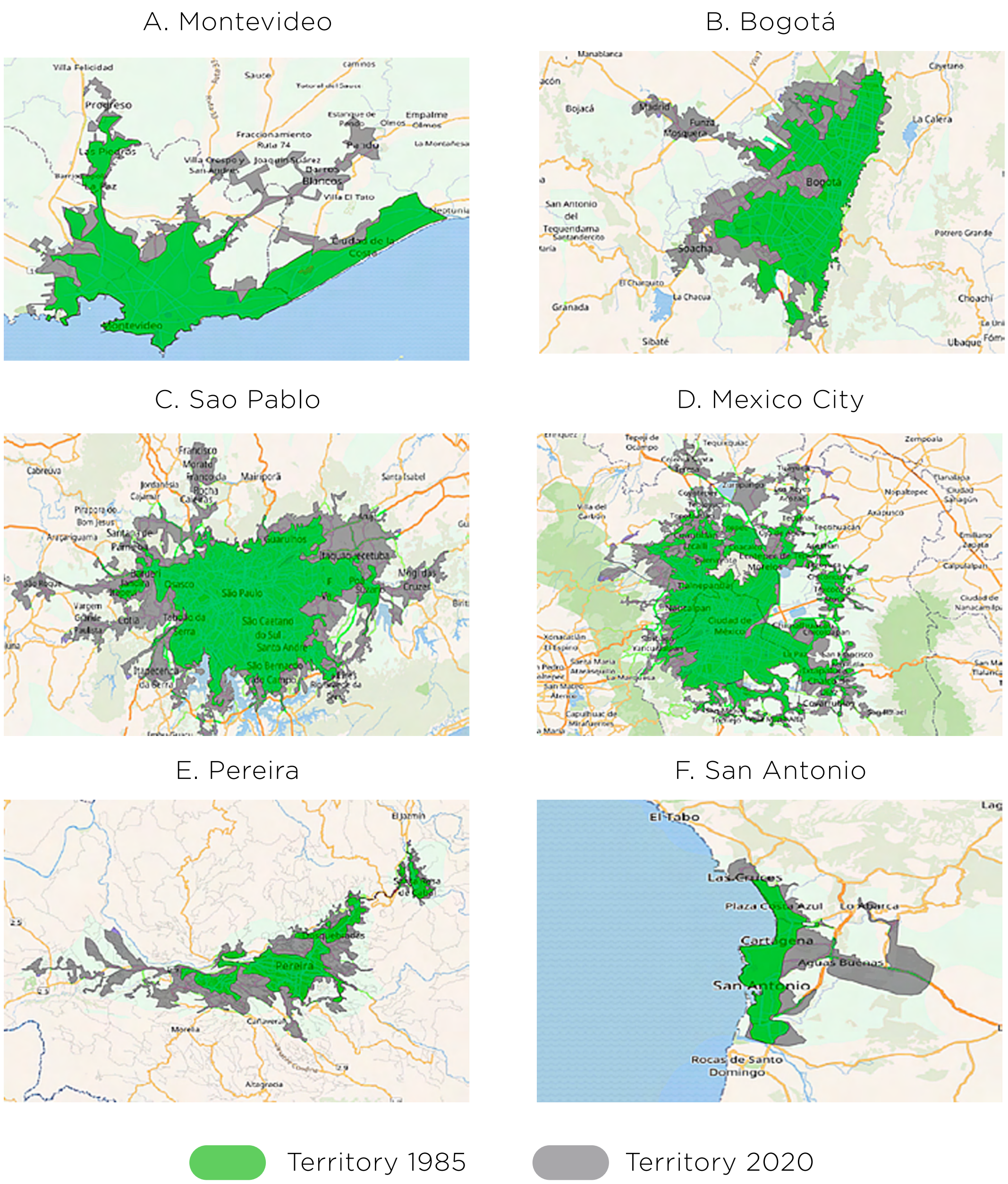
As the average income in LAC countries increased, so did preference for the automobile. Although the number of passenger vehicles in the region (159 vehicles per 1,000 inhabitants) is below the values reported by advanced economies such as Europe and the United States (555 and 351 vehicles per 1,000 inhabitants, respectively), the growth rate between 2015 and 2020 in LAC has been higher than that of advanced economies (9% versus 3%, respectively) (World Bank, 2023b; OICA, 2023), favored by an increase in the disposable income of the middle classes (Ferreira et al., 2012). Likewise, in several cities in the region, private mobility participation has grown to the detriment of public transportation use. In Bogota, for example, private mobility increased its share of total travel from 16% in 2005 to 23% in 2015, while public transportation declined from 57% to 45% over the same period (Rivas et al., 2019). Also worth noting is an increase in the fleet of motorcycles and three-wheeled vehicles in the region, which present a more affordable option for private mobility, with registrations rising by 23% between 2013 and 2016, while those of four-wheeled vehicles rose by 8% (WHO, 2019). In addition, the COVID-19 pandemic brought about changes in the field of mobility that reinforced these trends. In particular, the pandemic favored individual modes of transportation, a rise in the use of motorcycles, and home delivery services in different Latin American cities (Cuadros et al., 2023).

1.2.2 URBAN DEVELOPMENT FACTORS

In terms of urban mobility, fast urbanization rates, coupled with the lack of land-use planning and the deterioration of public transportation systems, have led to a sustained increase in motorization. Between 1950 and 2021, LAC's urban population went from 41.3% to 81% of total population and is expected to rise to 87.8% by 2050. In parallel, the region's cities have experienced a process of territorial expansion characterized by low population density and informal settlements in peripheral areas (Figure 1.10)

(Giraldez et al., 2022). In general, this process has not been accompanied by integrated land-use planning and transportation provision. As a result, peripheral areas are inadequately connected by public transportation networks, and their low density makes the operation of such services unprofitable. This has led to longer distance journeys for those seeking access to services and job opportunities, pushing up the demand for transportation.

FIGURE 1.10. **Territorial expansion of urban areas in LAC**



Source: Giraldez et al. (2022).

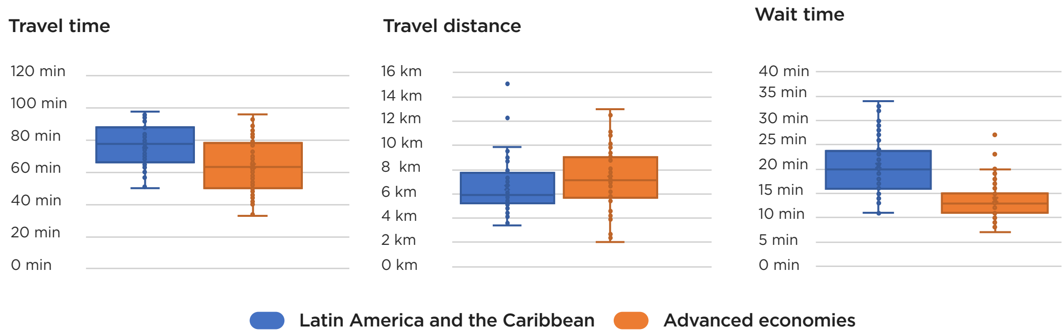
The evoluion of cities, in terms of urban form and population density, impacts the development of transportation systems. Despite population growth in the region's main capitals, changes in urban density differ among them. For example, between 2000 and 2018, density increased 10% in Bogota and 5% in Sao Paulo, but declined 13% in Mexico City, 8% in Lima and Santiago, and 6% in Buenos Aires (Bocarejo, 2020). Differences in population density have an impact on the organization of cities and the development of transportation systems. Indeed, in a sample of 300 cities from Brazil, Chile, Colombia and Mexico, higher car rates were associated with more complex urban forms and street networks, and a negative association was found between the 2010-2015 increase in car rates and the population density of cities, suggesting that low-density areas have been experiencing a greater increase in car rates in the cities examined (Delclòs-Alió et al., 2023).

1.2.3 TRANSPORTATION DEVELOPMENT FACTORS

Allocation of space to road infrastructure has favored the automobile over public and active transportation. According to the latest available data, the road network of the 29 largest metropolitan areas in LAC is 277,000 km long, of which less than 1% is dedicated exclusively to public transportation and only 1.2% corresponds to infrastructure for active mobility (Estupiñan et al., 2018). This prioritization in infrastructure allocation has resulted in greater competitiveness of the car compared to alternative modes of mobility. An analysis of cities with different sizes in the region shows that automobiles offer shorter travel times than public transportation in 9 out of 10 typical trips (Giraldez et al., 2022).

The level of service of public transportation is lower in the region than in many advanced economies, discouraging its use. Despite its coverage, there are deficiencies in terms of transportation fleet, accessibility, reliability, and passenger safety. The average age of the surface public transportation fleet exceeds 15 years, reaching more than 20 years in some countries (versus 11.4 years in Europe). This affects the perceived level of comfort and safety for users, while reducing the operational efficiency of the fleet. Accessibility to transportation is also limited, particularly affecting low-income residents of peripheral areas, who often must resort to informal transportation to get around. In the region, people travel the same distance in a longer time, while the average wait time is higher and has wider variability (Figure 1.11). This affects service reliability, which generally gets poor evaluations from users (Rivas et al., 2019).

FIGURE 1.11. **Travel time, travel distance, and waiting time for public transportation in LAC and advanced economies**



Source: Rivas et al. (2019).

These trends discourage the adoption of more sustainable modes and contribute to increasing CO2 emissions from urban mobility. Private transportation is the largest contributor to emissions in some of the region's major cities (Box 1.2). According to estimates by Giraldez et al. (2022), automobiles are responsible for 67% of total urban mobility CO2 emissions, although they represent only 26% of the trips. Likewise, the increase in motorization has aggravated congestion in the region, with the consequent impact on pollution. Indeed, Bedoya-Maya et al. (2022b) have shown a positive relationship between urban congestion and local pollution in LAC megacities, where a 1% increment in hourly road congestion levels is associated with a raise of 0.13% in CO levels, 0.16% in nitrogen dioxide (NO2), and 0.19% in PM10 during the same hour.

BOX 1.2.

Pollutant emissions in LAC cities

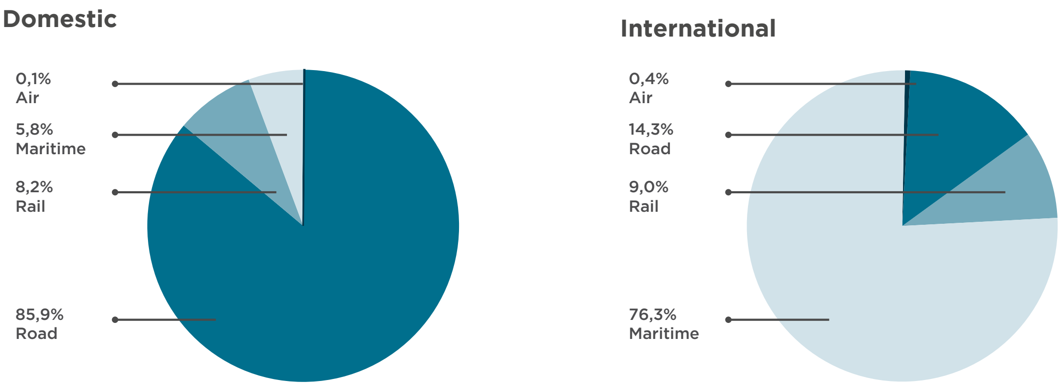
A closer look at the situation in LAC cities allows identifying the biggest sources of transportation emissions. Giraldez et al. (2022) compared the total CO2 emissions generated by buses and automobiles on a regular day in Mexico City, Sao Paulo, Bogota, and Montevideo using OD survey data, distances traveled, average demand, and CO2/km emission rates according to EEA (2019). The authors' estimates reveal that the car is the most polluting mode in the four analyzed cities, producing 67% of total CO2 emissions from urban mobility, while accounting for only 26% of trips. This represents 98% of the emitted CO2, controlling by the number of users mobilized. While these findings indicate that CC requires immediate public policy efforts in favor of more sustainable modes, the direction of infrastructure investments and lack of integrated land use and transportation planning have contributed to a reduction in the relative competitiveness of public transportation. Investment in transportation infrastructure in the region has been concentrated on road infrastructure for cars (96%), giving them greater competitiveness over public transportation in terms of travel times and distances covered above 800 meters (Giraldez et al., 2022). This is detrimental to the required mode shift towards more socio-environmentally sustainable modes, such as mass and active transportation (Cavallo et al., 2020).

The modal matrix imbalance explains the preponderance of road transportation in the sector's emissions. This mode is used in 85.9% of domestic goods movements. Likewise, it concentrates 30% of intraregional trade in South America and practically all exchanges in Central America (Calatayud & Montes, 2021). The share of rail freight in the modal matrix is small, focusing on bulk transportation and mining in a few LAC countries, and accounting for 8.2% of the total 4.3 trillion of domestic tonne-km transported (Figure 1.12). Air freight transportation accounts for just 0.1% of total tonnes transported (although it represents 3.3% of the CO2 emissions of the transportation sector). River transportation is relevant in countries such as Argentina, Brazil, and Paraguay, but represents only

2.6% of the total tonne-km transported, which is a low share considering the wealth of waterways in the region. With regard to international freight movements, they are led by maritime transportation (76.3%), followed by road transportation (14.3%), rail transportation (9.0%), and air transportation (0.4%).

FIGURE 1.12.

Modal split of freight transportation in LAC (2019)



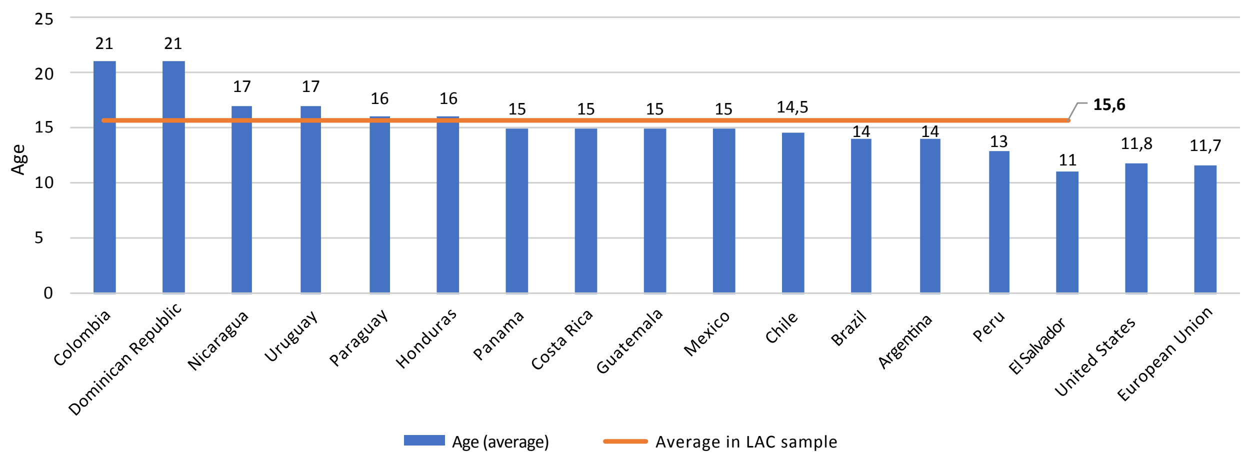
Source: Prepared by the authors based on data from ITF (2023a).
Note: Modal partition calculated from tonne-km of transported cargo.

Inefficiencies in freight transportation contribute to higher emissions from the sector. In the region, occupancy values of road freight transportation are on average in the range of 40% of empty vehicles-km, above the approximate average of European countries (25%) and North America (20-25%). This adds to the scarce incorporation of technology for load and route allocation, and to inefficiencies from delays in loading and unloading operations (Barbero et al., 2020). On the other hand, delays in loading and unloading processes in ports and logistics terminals, in the entry and exit of urban nodes, and at border crossings hinder the path to progress towards greater energy efficiency in the sector.

The region's vehicle fleet age impacts the level of emissions in the sector. The average age of the truck fleet is around 15.6 years, compared to 11.7 years in the European Union (EU) (Figure 1.13). Older vehicles are associated with lower energy efficiency, higher levels of emissions, and lower levels of safety and quality of service. An additional challenge is the state of road infrastructure in the region: only 33.2% of road kilometers are paved in LAC, half of OECD countries (74.75%). Road infrastructure quality has a direct impact on vehicle emission levels, which rise 2.5% on average when vehicles travel on poor-condition roads (Setyawan et al., 2015). Lastly, in relation to private vehicles, importing used units with lower quality standards compared to those applicable in the countries of origin generates a particularly important challenge for countries in Central America and the Caribbean (Box 1.3).

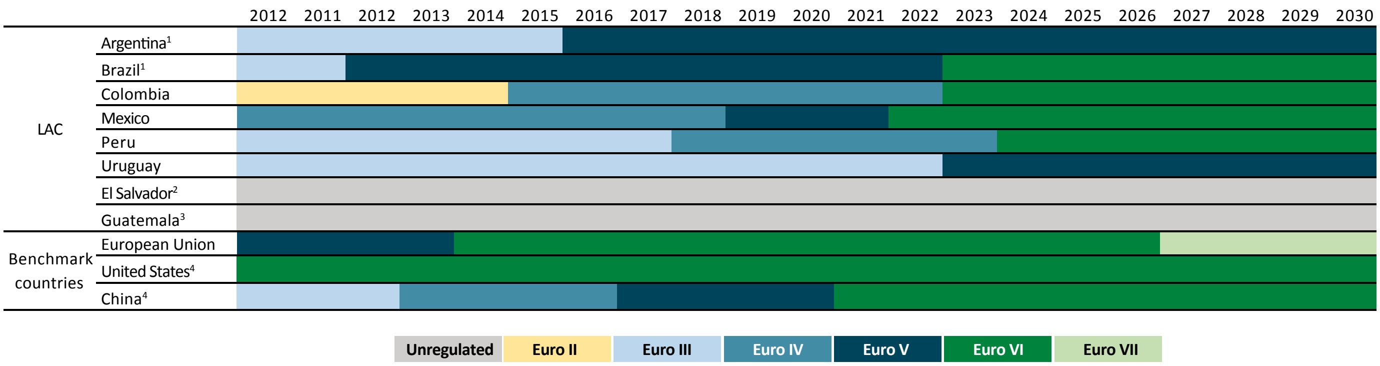
Regulations on emission standards affect the composition of the vehicle fleet and its emissions. An analysis from nine LAC countries shows that most diesel freight vehicles do not meet Euro II emission standards (Barbero & Guerrero, 2017). Meanwhile, trucks in Europe must meet the Euro VI standard and will be required to comply with the Euro VII standard starting on 2027 (see Chapter 4, section 4.2.1.). These differences have a vast impact on emissions, as complying with the Euro VI standard in diesel implies an 81% reduction in CO, NOx, and hydrocarbon emissions, as well as a 96% reduction in PM compared to the Euro I standard. While the evolution of required emission standards is uneven between countries in the region, overall they are behind those adopted by benchmark countries in the EU and the United States (Figure 1.14).

FIGURE 1.13. **Average age of the road freight fleet (selected countries)**



Source: Prepared by the authors based on data from: Colombia, Dominican Republic, Nicaragua, Paraguay, Honduras, Panama, Costa Rica, Guatemala and El Salvador (Barbero & Guerrero, 2017); Uruguay, Mexico, Chile, Brazil, Argentina, EU and United States (Barbero et al., 2020); Peru (IDB, 2015)

FIGURE 1.14. Year of implementation of emission standards for heavy-duty vehicles



Source: Prepared by the authors based on data from: Argentina, Brazil, Colombia and Mexico (López et al., 2022); Peru (Transport Policy, 2023); Uruguay (IMPO, 2008, 2021); El Salvador and Guatemala (UNEP,2020); EU, United States and China (Miller & Braun, 2020; Miller & Jin, 2019).

Notes: (1) In practice, Argentina and Brazil leapfrogged from Euro III to Euro V standards due to a delay in the implementation of Euro IV standards (Façanha, 2016; Transport Policy, 2023). (2) The mandatory Salvadoran emission standard refers to the type of fuel used by the vehicle and not to emission standards (Ministerio de Medio Ambiente y Recursos Naturales, 2021). (3) The Ministry of Environment and Natural Resources of Guatemala has a draft on public transportation emissions regulations, but it has not yet been formalized (Ministry of Environment and Natural Resources, 2013). (4) Regulations used in the United States and China correspond to the equivalent of the Euro standard.

BOX 1.3. Used vehicle imports in countries of the region

Of the total vehicles exported worldwide between 2015 and 2018 -corresponding to 14 million light vehicles–, 9% went to LAC (UNEP,2020). Used-vehicle import policies vary from country to country: some prohibit importing used vehicles, while others, such as Costa Rica, Haiti, Panama, and Suriname, set no age limits to restrict the entry of vehicles (Table 1.3.1). In particular, Central American and Caribbean countries have greater flexibility in terms of age limit for used vehicle imports, allowing the entry of those exceeding 5 years.

Importing used vehicles generates a barrier to decarbonize the transportation sector. For the most part, these vehicles are more polluting and generate negative impacts on road safety (an aspect not normally considered as part of import regulations). For example, in Guatemala, it has been observed that the increase in emissions from the vehicle fleet has been driven by imports of used vehicle that are more than 10 years old (Anaya, 2018). The average age of the vehicle fleet in Guatemala is 19 years, and in 2020 used vehicles accounted for 19% of total imports of new and used cars (ICEX, 2021). On the other hand, without considering the countries prohibiting used vehicle imports, only four countries in the region have regulations on emissions from imported vehicles: Bolivia (Euro II standard), Costa Rica, Mexico, and Peru (Euro IV) (UNEP, 2020). Therefore, it is essential that countries advance in the regulation of the used vehicle market to ensure its alignment with climate objectives of the transportation sector.

TABLE 1.3.1. **Age restrictions for importing used vehicles into LAC countries**

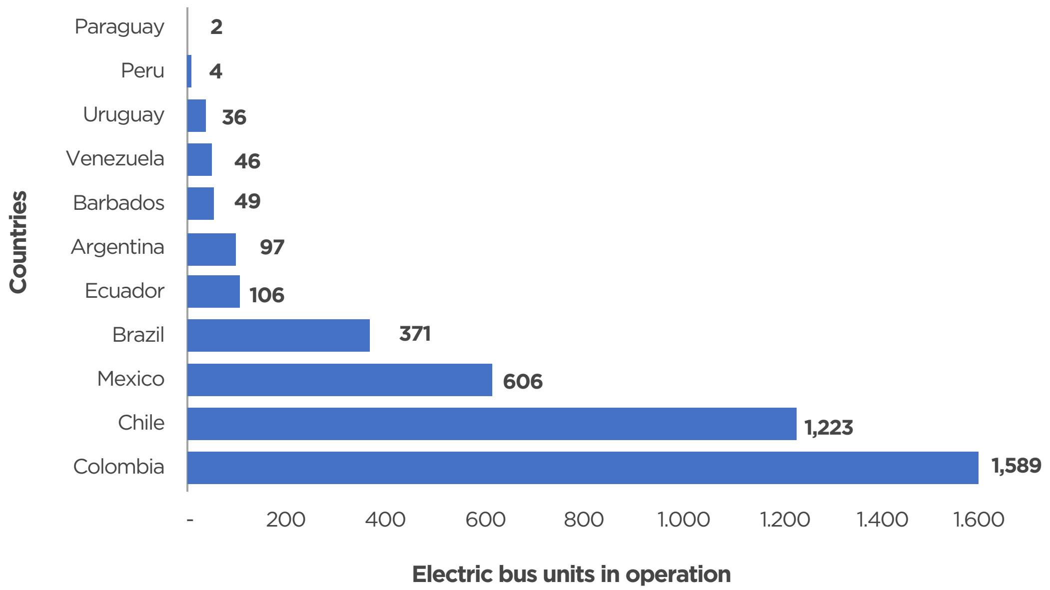
Import age limit	Countries
Prohibited	Argentina, Brazil, Chile, Colombia, Ecuador, Uruguay, Venezuela
4 and 5 years	The Bahamas, Barbados, Belize, Bolivia, Jamaica, Peru, Dominican Republic, Trinidad and Tobago
6 - 8 years	El Salvador, Guyana, Honduras
More than 9 years	Guatemala, Mexico, Nicaragua, Paraguay
No age limit	Costa Rica, Haiti, Panama, Suriname

Source: Prepared by the authors based on UNEP(2020).

1.2.4 TECHNOLOGICAL DEVELOPMENT FACTORS

The adoption rate of zero- and low-emission technologies lags far behind that of benchmark countries. While 5.9 million zero- and low-emission light vehicles were registered in 2022 in China, and 3.5 million in Europe and the United States, less than 40,000 units were registered in LAC (BEV and PHEV, battery electric vehicle and plug-in hybrid electric vehicle, respectively) (IEA, 2023d). Regarding electric buses and trucks, China continues to lead the pack, with a total 54,000 electric buses and 52,000 electric trucks registered in 2022, accounting for about 80% and 85% of global sales, respectively (IEA, 2023a). With respect to the stock of buses registered by 2023, China reports a total of 770,000 units and Europe 15,100 units (IEA, 2023d), while in LAC the stock amounts to 4,100 units (E-BUS RADAR, 2023). Within the region, Colombia and Chile lead the electrification of public transportation (see Chapter 5, Box 5.3). Other countries such as Mexico, Brazil, Ecuador, Argentina, Barbados, Venezuela, Uruguay, Peru, and Paraguay have made progress in electrifying public transportation, but on smaller scales (Figure 1.15), and mostly in pilot format. The pilots have allowed cities to test electric vehicles in real operating conditions and understand the risks and opportunities associated with their operation. Adoption of these new vehicle technologies took place under a variety of financing and contracting mechanisms, as well as business models for fleet acquisition and operation (Table 1.1). Among these, the most prevalent in the region were business models separating fleet acquisition from operation, using operator private financing for charging infrastructure and yards, and using public funds to pay for operation through fees and complementary subsidies (UNEP, 2022).

FIGURE 1.15. Electric bus adoption in LAC countries



Source: Prepared by the authors based on (E-BUS RADAR, 2023).

TABLE 1.1. Electric bus deployment models in LAC countries

Country	Acquisition and operation of fleets	Charging infrastructure and yards	Operation payment
Argentina	Public investment and operation	Pre-existing public infrastructure	Tariff + subsidy
Barbados	Public investment and operation	Public investment	Tariff + subsidy
Brazil	Concession partnership with energy company for transportation operation, Concession for integral transportation operation	Private financing by operator	Tariff + subsidy

Chile	Concession partnership with energy company for transportation operation, Fleet provision separate from fleet operation	Private financing by operator	Tariff + subsidy
Colombia	Fleet provision separate from fleet operation	Private financing by operator	Tariff + subsidy
Mexico	Public investment and operation, Fleet provision separate from fleet operation	Pre-existing public infrastructure	Tariff + subsidy
Uruguay	Concession for integral transportation operation	Private investment bus provider	Tariff + subsidy

Source: Prepared by the authors based on UNEP (2022).

Note: Public infrastructure existing prior to the implementation of charging infrastructure refers to catenary networks or overhead cabling.

Electric mobility incentives are at different stages of development in different countries in the region. There is consensus that the development of an incentive framework is vital for the deployment of technology in its early stages. The battery of instruments used to incentivize electric mobility varies between countries of the region, depending on existing regulations and incentives (Table 1.2.). In general, countries have shown a degree of progress in the development of Electric Mobility Strategies, in the elaboration of specific laws for the promotion of electric vehicles and charging infrastructure, and on tariff incentives for imports and taxes, with less progress in relation to differentiated electricity tariffs.

TABLE 1.2. State of Electric Vehicle Policies and Incentives in LAC Countries

Policies and incentives		Brazil	Chile	Colombia	Costa Rica	El Salvador
National policies and regulation	Electric Mobility Strategy	No	Yes	Yes	Yes	No
	Law to Promote Electric Vehicles (Draft or Aproved)	Yes	Yes (approved)	Yes (approved)	Yes (approved)	Yes (approved)
	Freight infraestructure regulation	Yes	Yes	Yes	Yes	Yes
Fiscal incentives	Tariff incentives for imports	Yes	No	Yes	Yes	Yes
	Tax incentives (purchase, sales, others)	Yes	Yes	Yes	Yes	Yes
	Differentiated electricity tariffs	No	No[1]	No[2]	Yes	Yes

Policies and incentives		Guatemala	Honduras	Mexico	Nicaragua	Panama	Uruguay
National policies and regulation	Electric Mobility Strategy	Yes (draft)	Yes (draft)	Yes	No	Yes	No[3]
	Law to Promote Electric Vehicles (Draft or Aproved)	Yes (approved)	Yes (draft)	No	Yes (approved)	Yes (approved)	No[4]
	Freight infraestructure regulation	Yes	No	Yes	No	Yes	Yes
Fiscal incentives	Tariff incentives for imports	Yes	No	Yes	Yes	Yes	Yes
	Tax incentives (purchase, sales, others)	Yes	No	Yes	Yes	Yes	Yes
	Differentiated electricity tariffs	Yes	No	No	No	Yes	No[5]

Source: Prepared by the authors based on data from: Brazil (Chamber of Deputies, 2023; Gramkow & Oliveira, 2023); Chile (Ministry of Energy, 2021a, 2021b); Colombia (Ministry of Environment and Sustainable Development, 2019b, 2019a); Costa Rica (Viscidi, 2021); El Salvador (Legislative Assembly of the Republic of El Salvador, 2021); Guatemala (Congress of the Republic of Guatemala, 2022); Honduras (MOVE, 2022); Mexico (Carrillo et al., 2020); Nicaragua (National Assembly of the Republic of Nicaragua, 2022); Panama (National Assembly of the Republic of Panama, 2022); Uruguay (Ministry of Environment, Eastern Republic of Uruguay, 2021; Ministry of Economy and Finance, 2020; MOVES, 2022).

Notes: (1) Chile's National Electromobility Strategy proposes actions for the next few years related with hourly rates for electromobility and efficient integration with the electricity grid. (2) According to the National Strategy for Electric Mobility of Colombia, an energy consumption tariff scheme for electric vehicles should be defined in 2022. However, it has not been established to date. (3) Although Uruguay does not have an Electric Mobility Strategy, it has a Long-Term Climate Strategy and an Electric Mobility Guide in Uruguay within the framework of the NUMP Uruguay project (Euroclima+/GIZ). (4) Although Uruguay does not yet have a law to promote electric vehicles, it does have an Investment Promotion Law (Decree 268/020) granting benefits to projects that include investments in electric utility vehicles, as well as a differential tax treatment for electric vehicles (Decree 370/021). (5) Uruguay offers a discount on the connection fee of new supplies or an increase in contracted power associated with the charging power of the vehicle or the installed charging system.

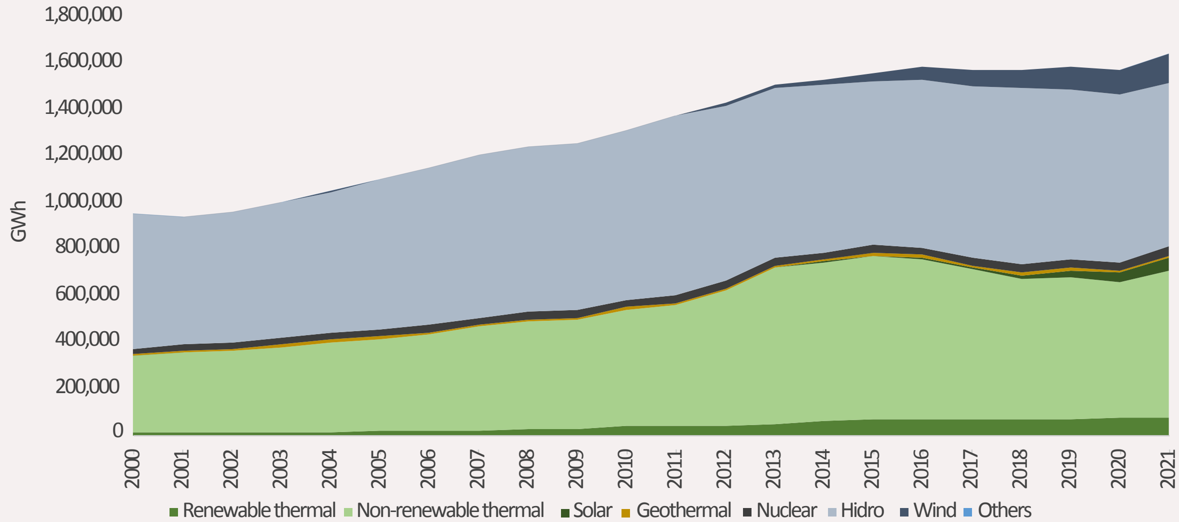
The development of electric mobility represents a great opportunity in a region with one of the cleanest energy production matrices in the world. In LAC, more than a quarter of primary energy comes from renewables, twice the global average (IRENA, 2016). In 2021, renewables accounted for 59% of power generation in LAC (predominantly hydropower) (Box 1.4). In contrast, renewables accounted for 29% of global electricity generation (IEA, 2021). While hydropower and biofuels have been highly relevant in LAC, countries in the region are expanding their matrix to other renewable energy sources, such as solar, wind, and biomass-based electricity. Brazil, Chile, and Mexico ranked among the top ten global renewable energy markets in terms of investment in recent years, and several countries such as Costa Rica, Uruguay, and Paraguay generate virtually all electricity through renewables (IRENA, 2022). This increase in renewable energies within the energy matrix of countries is seen as an opportunity to contribute to economic growth, energy security, and decarbonization of the region, especially in the transportation sector (Zhang et al., 2018).

BOX 1.4.

Transportation and electricity matrix in LAC

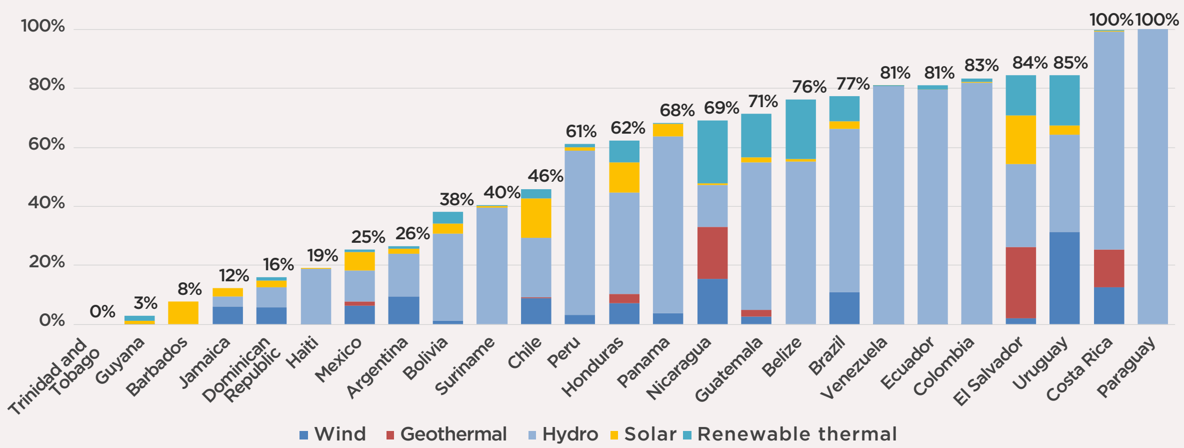
An electric bus does not produce emissions from the tailpipe, but emissions can occur in the generation and transmission of that electricity. Therefore, it is important to consider the emissions known as Well to Tank (WTT) when evaluating the GHG impact of that electric bus, and of transportation in general. In LAC, 59% of electricity generation comes from renewable sources, of which 73% comes from hydroelectric power plants, 13% from wind generation, 6% from solar generation, 8% from biomass, and 1% from geothermal energy (Figure 1.4.1.). Solar energy has experienced the greatest growth in the 2011-2021 decade, at an average annual rate of 132%, while wind energy has also grown significantly, at an average of 40% for this period. Despite the high share of renewable sources in electricity generation, the region average hides differences between countries. At the low end are Trinidad and Tobago with 0% of electricity generation from renewable sources, Guyana (3%), Barbados (8%), Jamaica (12%) and Haiti (19%), while at the other end are Costa Rica and Paraguay, with 99.98% and 100% of electricity originating from renewable sources, respectively (Figure 1.4.2) (Energy Hub, 2023). As the penetration of electric mobility increases, carbon intensity in electricity generation will become increasingly relevant to the analysis of the transportation sector’s total climate impact.

FIGURE 1.4.1. **Electricity generation by source in LAC (2000-2021)**



Source: Prepared by the authors based on Energy Hub (2023).

FIGURE 1.4.2. **Electricity generation from renewable sources in LAC (2021, by country)**



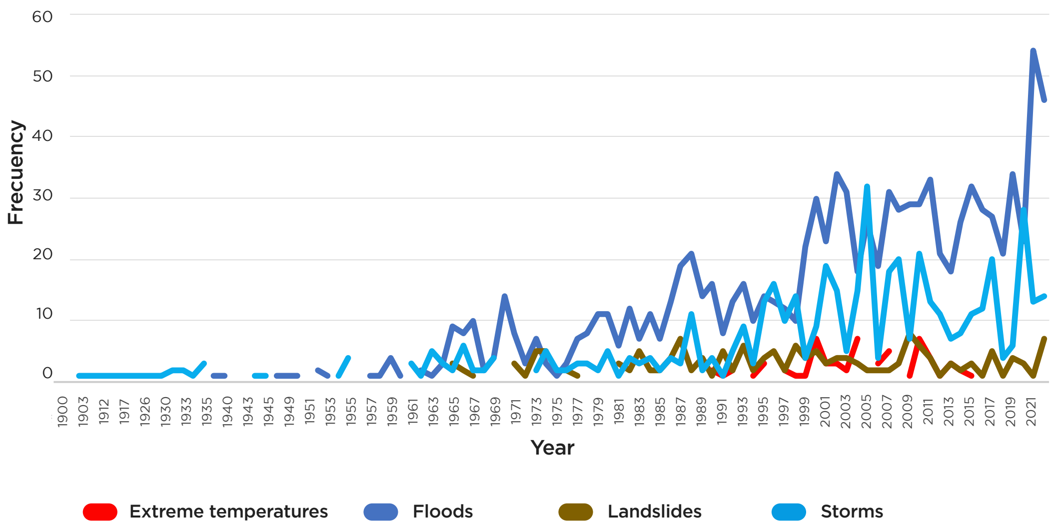
Source: Prepared by the authors based on Energy Hub (2023).
Note: Includes wind, geothermal, hydro, solar, and renewable thermal.

1.3.
CC impact on LAC's transportation sector

Despite contributing with only 5% of global CO2 emissions from fossil fuel combustion, the region is significantly affected by CC's negative effects (IEA, 2022g; IPCC, 2014a). The region's average temperature went from rising 0.1°C per decade between 1961 and 1990, to growing 0.2°C per decade between 1991 and 2021, while the average sea level is growing at rates above the global average (WMO, 2022). LAC is increasingly experiencing natural disasters (Figure 1.16), with countries such as Brazil, Colombia, Mexico, Peru, Argentina, and Haiti accounting for the highest frequencies of such disasters (Figure 1.17).

FIGURE 1.16.

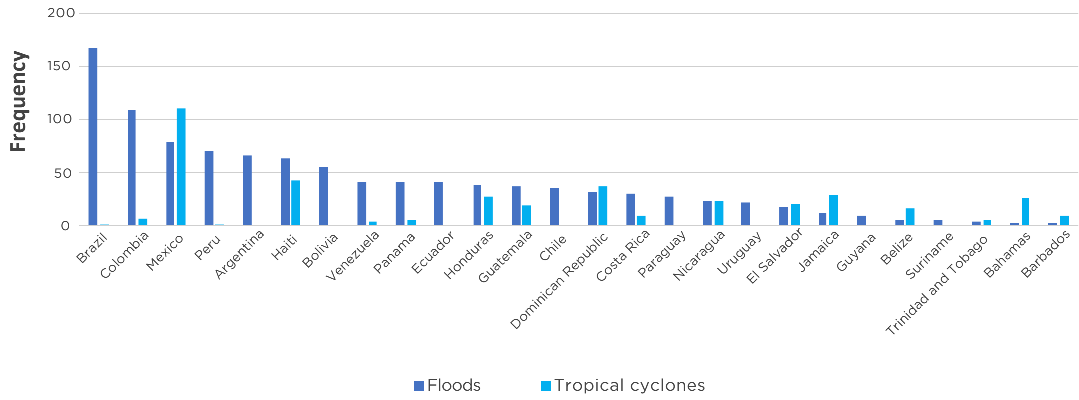
Historical evolution of the annual frequency of floods, storms, landslides, and extreme temperatures in LAC (1900-2021)



Source: Prepared by the authors based on natural disasters data from EM-DAT (2023).

FIGURE 1.17.

Number of floods and tropical cyclones experienced by LAC countries since 1900



Source: Prepared by the authors based on natural disasters data from EM-DAT (2023).

During recent years, the impact of extreme weather events on transportation systems has resulted in huge losses for the region. It is estimated that 25% of losses caused by natural disasters in the region are faced by the transportation sector (CAF, 2018). Some examples of impacts on transportation infrastructure and services include:

• In the Dominican Republic, natural disasters that took place during 2016 and 2017 caused damages to transportation infrastructure estimated in USD 394 million (Olaya González et al., 2022).

• In The Bahamas, Hurricane Dorian (2019) caused USD 51 million in transportation infrastructure damage and USD 37 million in losses from transportation service disruptions (Deopersad et al., 2020).

• In Honduras, Tropical Storm Eta and Hurricane Iota (2020) caused USD 82 million in transportation infrastructure damage and USD 59 million in losses from transportation service interruptions (IDB, 2021).

• In Brazil, extreme winds and tides in the port of Santa Catarina have interrupted activities 76 times over the last 6 years, causing losses of between USD 25,000 and 50,000 for every 24 hours of interruption (IPCC, 2022).

Each transportation mode is affected in different ways by changes in average climate variables and the occurrence of extreme weather events. In turn, the negative effects of CC on each transportation mode generate different types of consequences for the economy and society. Understanding the different mechanisms by which CC generates damages to transportation infrastructure and operational disruptions is essential to develop appropriate adaptation policies and measures for the region. To illustrate these differences, Table 1.3 summarizes the main role played by each mode of transportation in the region, the main climatic variables that affect it according to the literature, and some examples of historical damages and losses due to extreme hydrometeorological events.

TABLE 1.3. Relevance, main types of CC impacts, and examples of historical impacts by transportation mode

Mode	Relevance	Main types of impact	Examples of historical impacts
Maritime	Access to international markets and economic growth. The maritime mode transports about 80% of the total annual volume of world trade (UNCTAD, 2018).	• Sea level rise generates temporary or permanent flooding risks • Tropical storms generate floods and severe winds that hamper operations and cause significant damage to structures and machinery • Extreme temperatures limit outdoor working hours and increase energy consumption • Drought limits river navigability	• The Bahamas: Hurricane Dorian (2019) generated USD 2.2 million in damage and USD 12.8 million in losses related with the maritime mode (Deopersad et al., 2020; UNCTAD, 2022b) • Honduras: Hurricane Iota and storm Eta (2020) caused USD 3.8 million in losses related with the maritime mode (IDB, 2021).
Air	International trade and regional and isolated area connectivity. Over the past two decades, air passenger transportation more than tripled and freight volume grew by 35% (Brichetti et al., 2021).	• Sea level rise generates flooding risk at airports • Extreme temperatures require longer take-off distances • Extreme precipitation results in longer distances between aircrafts • Thunderstorms generate delays due to route changes • Changes in wind patterns increase travel times and affect flight safety due to clear air turbulence	• The Bahamas: Hurricane Dorian (2019) generated USD 37 million in damage and USD 24 million in losses related with the air mode (Deopersad et al., 2020). • Honduras: Hurricane Iota and storm Eta (2020) generated USD 5.4 million in damage and USD 4.8 million in losses related with the air mode (IDB, 2021).

TABLE 1.3. **Relevance, main types of CC impacts, and examples of historical impacts by transportation mode**

Mode	Relevance	Main types of impact	Examples of historical impacts
Road	It absorbs more than 70% of domestic freight movements in the region, 30% of interregional trade in South America, and practically all exchanges in Central America (Calatayud & Montes, 2021). Predominant mode for interurban passenger mobility in LAC (IDB, 2020).	• Extreme rainfall saturates drainage systems, generating flooding, limiting speeds, and increasing the likelihood of crashes • Prolonged rainfall can cause soil saturation and landslides • Extreme temperatures accelerate asphalt pavement deterioration and thermal expansion of joints in bridges • Thermal amplitude accelerates concrete pavement deterioration by causing a non-uniform distribution of stress.	• Colombia: Extreme precipitation during 2010 and 2011 caused USD 1.6 billion in damage to road infrastructure, affecting more than 31,635 km of roads (Transport Ministry, 2014). • Paraguay: Extreme precipitation during 2015 and 2016 generated more than USD 220 million in damage to road infrastructure (CAF, 2018).
Urban	In LAC, the urbanization rate went from 41.3% to 80% of the total population between 1959 and 2015 (Calatayud et al., 2021). Urban transportation systems allow access to opportunities for work, study, goods and services (IDB, 2020), and at the same time are crucial for evacuation during disasters.	• Extreme rainfall causes flooding due to the large impervious surfaces present in cities, resulting in increased traffic congestion, interruptions in underground subway systems, and limitations for active transportation. Impacts may be stronger in coastal cities. • Extreme temperatures are accentuated by the heat island effect, generating accelerated pavement deterioration and higher maintenance costs. Extreme temperatures can also induce a shift from active modes and public transportation to the private vehicle.	• Buenos Aires: In 2013, the city experienced one of the most intense storms recorded during the last 50 years. Around 350,000 people were directly affected by flooded public transportation routes and mass transit service disruptions. Direct damage amounted to USD 300 million (World Bank, 2016). • Rio de Janeiro: High intensity precipitation is associated with a reduction in average bus speeds of between 1.03% and 7.30%, generating delays with an estimated annual cost of between USD 37 million and USD 54 million (Chaves Maia, 2022).

Source: Prepared by the authors.

1.4. Determinants of CC vulnerability for LAC's transportation sector

• 1.4.1 GEOGRAPHICAL LOCATION

Due to the geographical location of some countries that make part of the region, their transportation infrastructure is more exposed to the occurrence of extreme weather events. This is the case of Caribbean countries, which are located in the hurricane corridor, resulting in more frequent impacts on their coastal transportation infrastructure (see Box 1.5). Similarly, countries located in the equatorial zone experience more frequent extreme rainfall events, which in combination with their mountainous topography usually generate floods and landslides, mainly affecting road infrastructure.

BOX 1.5.

CC vulnerability for Caribbean countries

Caribbean countries, particularly those forming part of the Small Island Developing States (SIDS), are extremely vulnerable to the effects of CC. Due to their geographical location, these countries are highly exposed to extreme events such as cyclones, tropical storms, extreme winds, earthquakes, and tsunamis. Due to their size, higher proportions of their population and assets are located in low-lying coastal areas. For example, it is estimated that 32% of the land and 25% of the population of The Bahamas are located less than 0.5m above sea (Strauss & Kulp, 2018). A higher level of exposure of the population and assets means that SIDS suffer greater negative impacts from the occurrence of extreme events. For example, the 2017 hurricane season caused USD 320 billion in damage in the Caribbean (World Meteorological Organization, 2018). In The Bahamas, Hurricane Dorian caused USD 3.4 billion in damage and losses in 2019 (Deopersad et al., 2020). In the Dominican Republic, the expected annual damages from hurricanes amount to USD 345 million (World Bank, 2018).

Caribbean SIDS transportation infrastructure is located primarily in coastal areas, making it more vulnerable to mean sea level rise and extreme hydrometeorological events. Their transportation systems have very little redundancy, with ports and airports being the main means of supply for the population. Because of these characteristics, after the occurrence of extreme events, disruptions and recovery times are greater in these countries. Additionally, their economies are not very diverse, with tourism representing between 11% and 79% of their GDP (Monioudi et al., 2018). This causes the occurrence of extreme events to impact these economies more severely, including employment losses in the population (World Bank, 2017).

It is estimated that Caribbean SIDS will face more than USD 22 billion in annual losses by 2050 as a result of CC (Bueno et al., 2008). About 3,100 km2 of territory could be flooded in these countries, including 21 of 64 existing airports (Simpson et al., 2011). Additionally, projections indicate that a 1m increase in mean sea level could flood 80% of ports (Mycoo, 2017). Given the small size of these economies and the large costs associated with damages to their transportation infrastructure, these countries require significant financial support to recover their infrastructure after a disaster and implement adaptation measures to make it more resilient to future events. Due to resource limitations and high levels of debt, most SIDS do not have sufficient reserves to meet emergencies, limiting their capacity for immediate response and for the implementation of adaptation measures to the hazards imposed by CC (World Bank, 2017).

1.4.2 REDUNDANCY

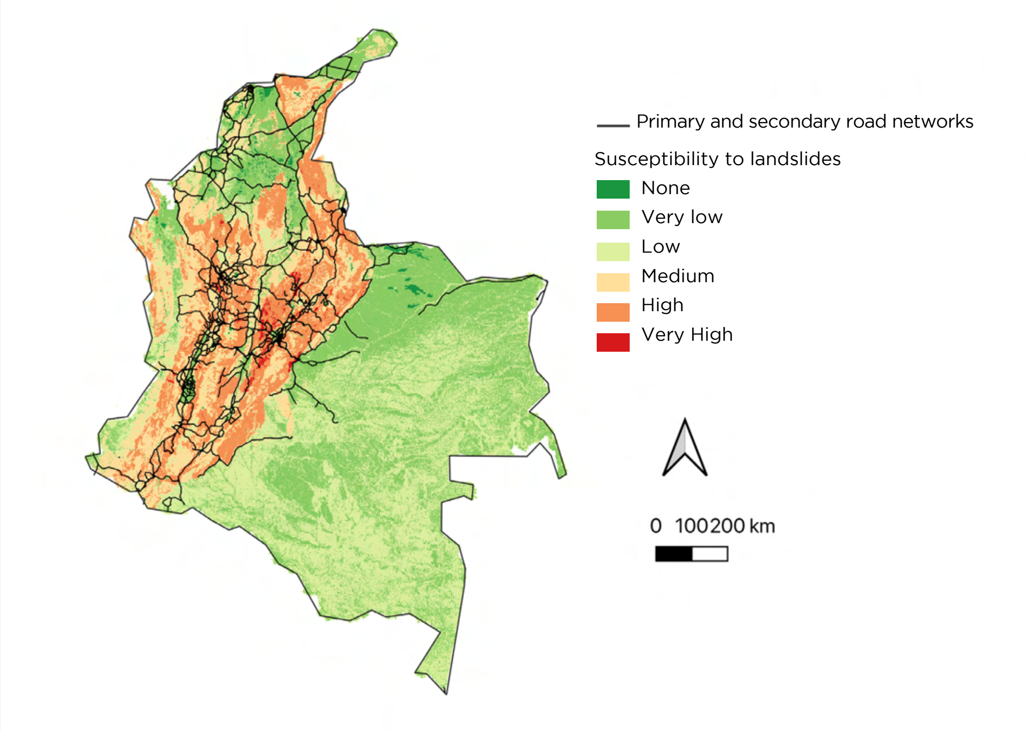
Resource constraints and deficiencies in planning processes mean that in many cases the region's transportation systems have little redundancy. Road closures can have a stronger impact on the economy and society when there is no alternative route in appropriate conditions to continue ensuring connectivity, as is the case in Colombia (Box 1.6). Similarly, in countries like Paraguay, dependence on river transportation, together with vulnerability to climatic phenomena, can have a major impact on the economy (Box 1.7). Investments to increase redundancy, improve maintenance, and adapt transportation systems are essential to make them more resilient, helping to resume service in a timely manner when extreme events occur.

BOX 1.6.

Redundancy analysis of Colombia's road network

Due to the country's topographic conditions and the geographical location of main population centers, much of Colombia's road network is built on mountainous terrain. For this reason, its roads are particularly susceptible to the effects of extreme rainfall and landslides (Figure 1.6.1). Additionally, Colombia is one of the countries with the highest levels of precipitation worldwide, so landslides causing the closure of main roads are quite frequent. In this context, having alternative routes is essential to guarantee the supply of goods and services whenever landslides or other extreme events block key segments of the road network.

FIGURE 1.6.1. **Susceptibility to landslides in Colombia in relation to road network location**



Source: Prepared by the authors based on road network data from OpenStreetMap contributors (2023), and landslide susceptibility data from IDEAM (2010).

The interruption of road segments in low redundancy areas can generate isolation and supply shortages in the most vulnerable communities. Figure 1.6.2 shows the results of a redundancy analysis performed on Colombia's main and secondary road networks. For each segment, the redundancy analysis calculated the extra distance that a vehicle would have to travel from the starting point to the ending point of the segment, if it was removed from the network. Excluding segments for which there are no alternatives (in dotted gray lines), segments in red are those with the lowest redundancy values, as vehicles would have to travel over 400 extra kilometers if blocked by some extreme event. Indeed, the lowest coverage and redundancy values of the primary and secondary road networks are found in the areas furthest from the country's economic centers, coinciding with the highest poverty rates. Around 65 municipalities

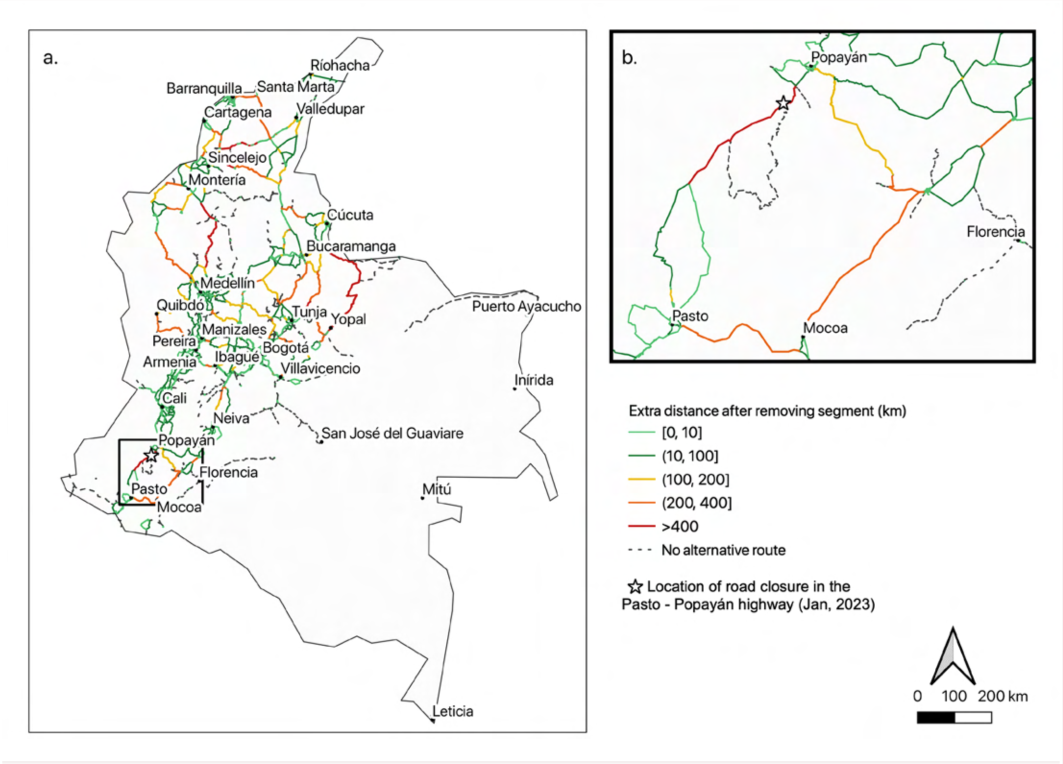
The interruption of road segments in areas of low redundancy can generate additional travel of 400km or more.

with multidimensional poverty values above 70%, located mainly in the departments of Amazonas, Caquetá, Vaupés, Guainía, Vichada, Nariño, Cauca, Chocó, Bolívar and La Guajira, do not have primary or secondary road network coverage and their closest routes have very low levels of redundancy.

The negative impacts of limited road redundancy are constantly experienced in the country. An example of this occurred at the beginning of 2023, when a segment of the highway that connects Pasto with Popayán was blocked due to a major landslide (Figure 1.6.2.b). This road segment is part of the Pan-American Highway, has a traffic volume of 3,700 plus vehicles per day (INVIAS, 2018), and is of great importance not only to provide supplies for the southwestern part of the country, but also to connect Colombia with Ecuador. The alternative route connecting Pasto with Popayán involves traveling the Pasto-Mocoa section, which presents safety challenges and is known to have a high crash rate. As a result of the total closure of the Pasto-Popayán road and the lack of alternative infrastructure, the southwestern part of the country was isolated from the center, making necessary to provide supplies by air.

FIGURE 1.6.2.

Extra distance that must be travelled when each segment is removed from the network



Source: Prepared by the authors based on road network data from OpenStreetMap contributors (2023). Shortest route calculations were made using the Pandana library (Foti et al., 2012).

Note: The map includes Colombia's primary and secondary road networks. The color of each segment indicates the additional distance a vehicle would have to travel from the starting point to the ending point of the segment, if it was removed from the network. Image "a" shows the results of the analysis for all of Colombia, while image "b" is a close-up of the Pasto - Popayán section, which in January 2023 was totally blocked by a landslide, generating disconnection between the south and the center of the country.

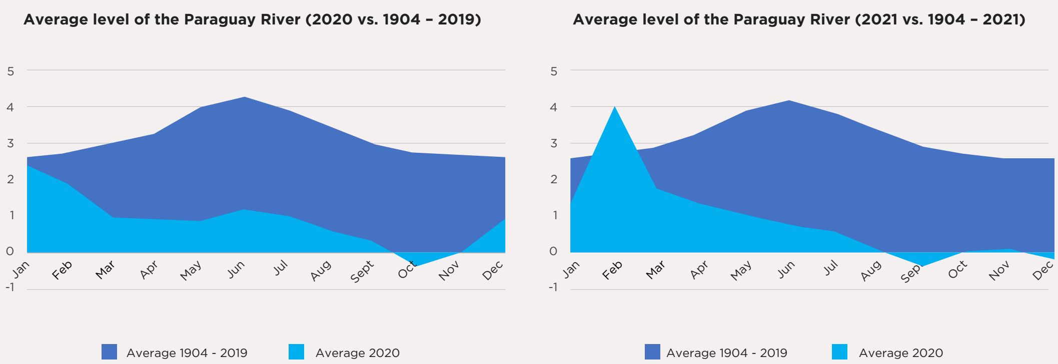
BOX 1.7.

Vulnerability of the Paraná-Paraguay Waterway and impact on Paraguay's economy

The Mediterranean nature of Paraguay makes the Waterway key to its international insertion. More than 75% of freight exports and imports move through this corridor, traveling on average 1,350 km to and from seaports. Therefore, the Waterway's navigability is a strategic factor for Paraguay's economy. However, the increased frequency of extreme weather events in the last decade has exposed the corridor's vulnerability, exerting adverse effects on trade. The maximum and minimum levels of the Paraguay River have been dropping since 2018, with historical declines during 2020 and 2021, when the river experienced its lowest average levels since 1904 (Figure 1.7.1). In October of 2021, the river experienced its historical minimum since 1904 (-0.75m). This affected navigability, leading to the closure of operations and the need to reduce ships' loading capacity by 60%, while doubling loading times (Franco et al., 2022). As a result, the prices of exported and imported goods went up, tripling the cost of freight (ABC Color, 2021). In order to reduce these risks, the Master Plan for the Navigability of the Paraguay River, currently under preparation, is expected to include priority actions in terms of CC adaptation.

FIGURE 1.7.1.

Comparison of average levels of the Paraguay River – Asuncion checkpoint (meters)



Source: Prepared by the authors based on Anuario Hidrológico 2020 (DINAC & DMH, 2021) and 2021 (DINAC & DMH, 2022).

1.4.3 DESIGN STANDARDS

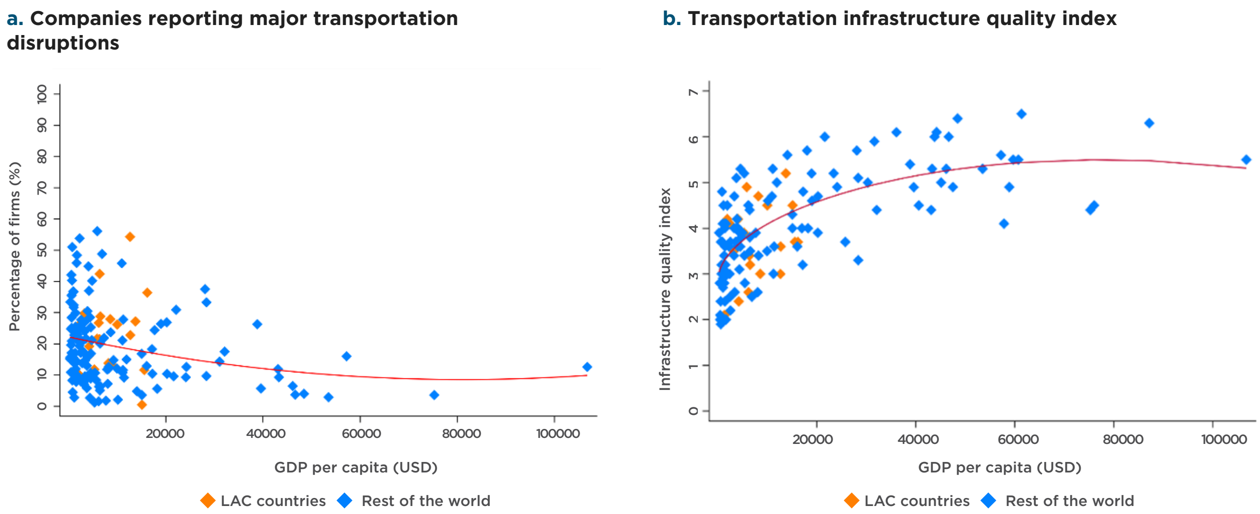
The region's existing transportation infrastructure has been designed under assumptions of constant weather. Although the design process usually considers the occurrence of extreme hydrometeorological events, it is traditionally assumed that an extreme event with a certain intensity has an exceedance probability (or return period) that does not vary with time. If the expected useful life of a given asset is 100 years, the design was probably made considering only those hazards with a return period equal to or less than 100 years for the base year. With extreme events being more intense and frequent due to CC, design assumptions are sometimes not met, causing infrastructure to fail sooner than expected. In this context, it is necessary to adjust design standards to accommodate for new demands associated with CC and ensure the resilience of the region's transportation systems (see Chapter 4).

Adapting existing infrastructure generates higher costs than incorporating adaptation from planning. The region's most expensive infrastructure assets such as bridges, tunnels, seaports, and airports will sometimes require significant investments in barriers, elevations, or location changes to withstand the unanticipated CC effects that will occur during their lifetime. Other assets such as roads will require increased maintenance frequency to counteract the effect of extreme temperatures and precipitation on accelerated deterioration and flooding. To minimize the retrofitting and maintenance costs, new infrastructure should be designed and built considering potential changes in the magnitude and return period of hazards due to CC, as well as employing new materials that are more resilient and choosing locations that seek to minimize exposure to hazards. Although designing for more extreme conditions will increase construction costs, in the long run this additional investment represents a minimal cost compared to the costs associated with adapting existing infrastructure (see Chapter 5, section 5.1).

1.4.4 ECONOMIC CONDITIONS

Transportation infrastructure disruptions are associated with economic development levels. Transportation infrastructure quality is directly associated with income level, with Chile, Panama, and Mexico having the highest transportation infrastructure quality indices in the region (Figure 1.18.b). On the other hand, lower-income economies, such as Bolivia, Paraguay, and Honduras, tend to have lower transportaion infrastructure quality indices and larger proportions of companies affected by major transportation disruptions (Figure 1.18.a). However, there are significant differences in the proportion of companies affected by transportation disruptions among countries with equal income levels. For example, Argentina (GDP per capita USD 12,716) has a small percentage of disruption reports comparable to that of many developing countries, while Costa Rica (GDP per capita USD 12,662) is among the most affected.

FIGURE 1.18. **Relationship between transportation disruptions, infrastructure quality, and GDP per capita**



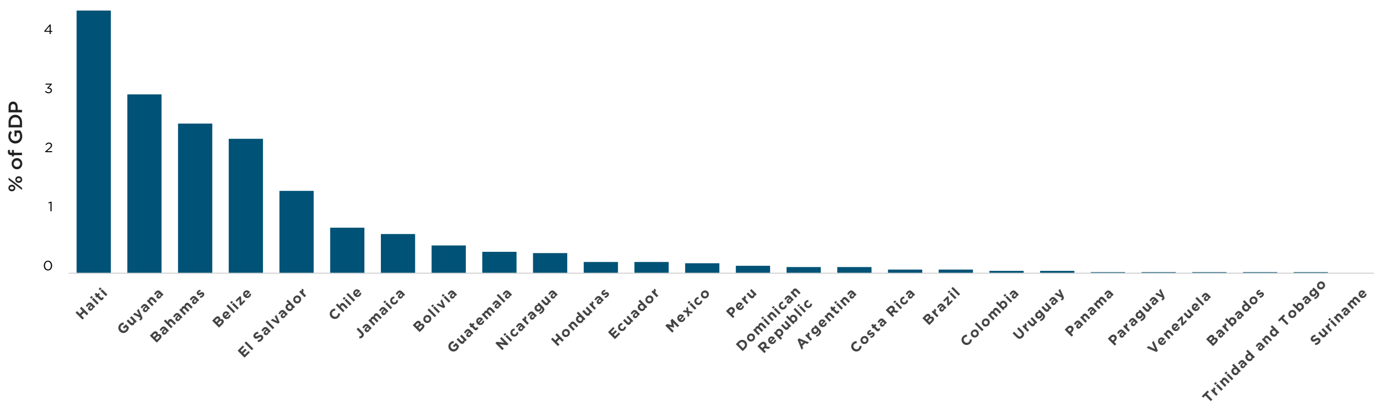
Source: Prepared by the authors based on Rentschler et al. (2019) using data from the World Bank Business Survey (panel a), and data on the Infrastructure Quality Index from World Economic Forum's Global Competitiveness Index (panel b).

Note: GDP per capita data expressed in USD at constant 2015 prices. Countries in the rest of the world only consider low- and middle-income countries.

CC impacts over the transportation sector have more serious consequences for lower-income countries. In general, transportation infrastructure has lower coverage and quality in these countries, which means that they have less redundancy to continue offering transportation services to people and companies after failures in a part of the system. Without sufficient transportation alternatives, lower-income countries experience longer disruptions in service provision and greater negative impacts on supply chains and the economy, resulting in higher costs and lower business productivity. Disruptions to transportation infrastructure are estimated to result in capacity utilization losses (operating below total company capacity) of USD 107 billion annually in low- and middle-income countries, representing 0.42% of these countries' GDP (Rentschler et al., 2019). In LAC, the capacity utilization rate decreases in a range of 0.4% - 0.8% due to disruptions in transport, electricity, and water infrastructure. Costa Rica faces the greatest utilization rate losses (approximately 0.9%) due to a less resilient transportation system, followed by Paraguay and Guatemala, with losses of approximately 0.8% in both cases (Hallegatte et al., 2019).

Lower-income countries have a harder time recovering from damage to transportation infrastructure. Natural disasters generate immediate disbursement needs to address emergencies in different sectors, against which governments must make prioritization decisions with limited resources. Repairing damages usually involves investing a larger percentage of GDP for small and lower-income countries. For example, Haiti, Guyana, The Bahamas, and Belize suffer annual damages from natural disasters exceeding 2 percent of GDP (Figure 1.19). Given the limitations in access to owned resources and financing mechanisms, as well as the significant investment needs experienced after an extreme event, low-income countries are often unable to repair their infrastructure immediately, and take longer to be able to offer the initial service again. Resource constraints also make it difficult for these countries to identify and implement adaptation measures that could increase the institutional capacity and resilience of transportation systems in the long term.

FIGURE 1.19. **Average annual damage caused by natural disasters**



Source: Prepared by the authors based on international data on natural disasters from EM-DAT (2023) and GDP data published by the World Bank (2021b).

Note: Damage figures correspond to natural disasters that took place between 2000 and 2023. The reported damage for a given country and year was compared with the country's GDP value for that same year, to get damage expressed in %GDP for each year and country. The damage values as %GDP were averaged for each country over the analysis period (including years with zero damage) to get the values in the figure.

Lower-income communities tend to have lower coverage of transportation services and are more affected by disruptions in service provision. For rural communities in remote areas, the closure of an access road due to damages from extreme weather events can lead to isolation, limiting access to goods and services (Box 1.6). Indeed, remote areas -rural and on the urban periphery– have higher prevalence of unpaved roads and streets, which increases their vulnerability to flooding during rainy seasons. In large cities, lower-income communities have a higher dependency on public transportation systems to access employment opportunities, goods, and services (Greenham et al., 2022). Additionally, these communities tend to be concentrated in peripheral areas where the coverage of these systems is lower than in central areas (Yáñez-Pagans et al., 2019). Given their reliance on few existing public transportation routes, these communities are more vulnerable to service disruptions, especially considering that such disruptions can prevent them from meeting their basic needs. An example of this can be seen in the case of Bogota, Colombia (Box 1.8).

BOX 1.8.

Relationship between income and public transportation disruptions due to flooding

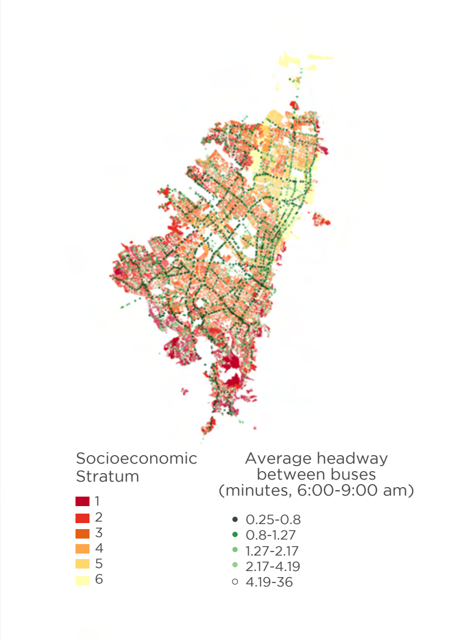
The analysis was done based on two maps that were generated for the city of Bogota: the first one shows the spatial distribution of income along with the average headway between public transportation vehicles for each stop of the city. The second one shows areas where rain waterlogging historically occurs, along with the average headway between public transportation vehicles for each stop.

Figure 1.8.1.a shows that areas concentrating lower-income households tend to be located on the outskirts of Bogota, with less coverage and frequency of public transportation services. Figure 1.8.1.b shows that areas which are historically more prone to flooding are located in the south and west of the city, coinciding with areas of concentration of low-income households. Given the lower coverage and quality of public transportation services in lower-income areas, as well as their greater susceptibility to flooding, residents of these areas are more likely to suffer isolation and limited access to opportunities and services during episodes of extreme precipitation.

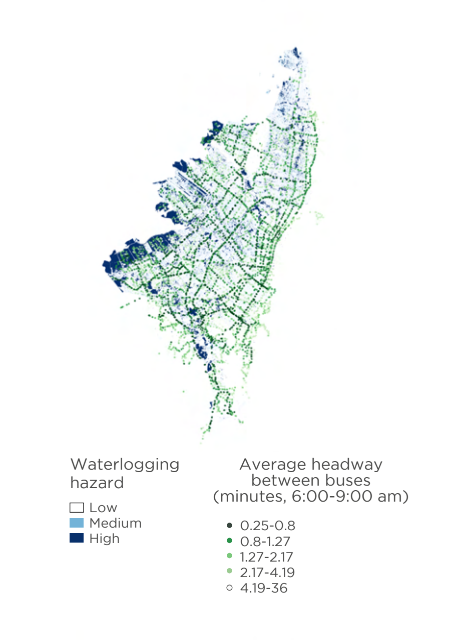
FIGURE 1.8.1.

Spatial distribution of income, average headway in public transportation stops, and waterlogging areas for Bogota

a.



b.



Source: Prepared by the authors with GTFS data from the District Secretariat of Mobility (2021), socioeconomic stratum data from the District Secretariat of Planning (2016), and waterlogging areas from the District Secretariat of Planning (2022).

Note: The socioeconomic stratum is a classification created by the city for the application of subsidies. Lower strata correlate with lower incomes.

Transportation emissions in the region have been growing from 281 MtCO2 in 1990 to 595 MtCO2 in 2019.

1.5. Conclusions of the diagnosis for LAC

• Transportation is key to reduce GHG emissions and fight against CC. With 25% of global emissions from fuel combustion, transportation is the second largest contributor of CO2, behind electricity and heating generation.

• LAC has a small share of the total CO2 emissions of the transportation sector worldwide (9%). However, this share has increased by 112% between 1990 and 2019. The region's share in the global total went from 7% to 9% between 1990 and 2019, while North America and Europe –starting from higher levels of emissions– showed significant decreases (-11% and -7%, respectively). Likewise, the transportation sector is the largest source of GHG emissions in the region, accounting for 40% of total emissions.

• Within LAC's transportation sector, road transportation is the main contributor to CO2 emissions, accounting for 94% of the total. This is similar to global values, which range from 82% in China to 98% in the Middle East. Domestic aviation contributes with 4%, domestic shipping with 2%, and rail with 1%. When differentiating between passenger and freight transportation, it can be seen that most of the CO2 produced by transportation in LAC comes from passenger transportation, mainly from road transportation.

• Unlike what is happening in Europe and the United States, in the region there is no decoupling between economic growth and emissions from the transportation sector, evidencing an intensive growth in emissions for LAC. However, it is important to consider that the decoupling analysis does not take into account the significant role of international trade, whose emissions are not assigned to any country, neither to producer nor to consumer countries. Yet, smaller economies are the most emission-intensive ones in the region.

• In addition to the impact of transportation on CC, emissions from the sector have a negative effect on air quality and public health. Although typically tackled separately, air pollution and CC are mostly caused by the same sources and present similar solutions, so it is important to approach them together with a special focus on people's health.

Children are specially affected, as empirical evidence shows an effect on increased asthma levels, lower lung functions, and a higher rate of premature deaths.

• The expansion of cities without adequate public transportation provision, low quality of public transportation, existing asymmetries in the allocation of road space –favoring private vehicles over public transportation and active mobility–, high levels of road congestion, vehicle fleet obsolescence, and low penetration of electromobility, result in lower transportation energy efficiency, emitting higher volumes of CO_2 per passenger and making transportation the main generator of emissions at the urban level.

• Transportation is also suffering from the effects of CC, which is generating huge losses for the region. Lower-income countries are particularly affected, owing to their geographical location, poor infrastructure quality, and low adoption of adaptation measures. Due to their limited resources, institutional weaknesses, and less preparation of contingency plans, these countries have greater difficulty both planning for resilient infrastructure and recovering from damages to transportation infrastructure in a post-event scenario. This results in significant impacts on the quality of life of their populations and the competitiveness of their economies.

• Vulnerable populations are the most affected. In rural areas, the closure of an access road after extreme weather events can limit access to goods and services. In large cities, lower-income communities tend to settle in areas with greater vulnerability to climatic events and lower penetration of public transportation. Given their dependency on the few existing public transportation routes available to access employment opportunities, goods, and services, these communities are more vulnerable to service disruptions, as such disruptions can prevent them from meeting their basic needs.

2.

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2.
The risk of not acting today

The forecasts of increased GHG emissions worldwide are alarming. Prior to the Paris Agreement, the international treaty adopted in 2015 by 196 countries to limit global warming, it was estimated that by 2100 the global average temperature would rise between 3.6°C and 4°C with respect to pre-industrial levels, generating a climate catastrophe. Technological developments in renewable and clean energy have reduced these figures, placing global warming between 2.7°C and 3.1°C by 2100. However, these levels are far from the 2°C – or preferably 1.5°C – set by the Paris Agreement. Reaching the 1.5°C limit implies that global emissions must be reduced by 80% by 2050, from 50 GtCO2 in 2019 to just 10 GtCO2 by that date (Plumer & Popovich, 2021). This means that global emissions should peak in the coming years (2025) and that global emissions from energy sources and industrial processes should be reduced by 40% by 2030, compared to the levels observed in 2019 (limiting emissions to 21 GtCO2, with an average annual rate of emission reductions of 1.7%) (IEA, 2022d), reaching net zero emissions by 2050. Under this scenario, the global transportation sector must reduce its emissions by 30% by 2030 compared to the emissions level in 2019, with road transportation (urban and interurban) accounting for 82% of this reduction (IEA, 2022d).

Global warming will have major consequences for transportation. Due to projected increases in mean and extreme sea levels, annual global costs related with impacts to seaports could reach values of up to USD 17.7 billion by the end of the century, equivalent to 70% of the net annual profits of container ports (Houtven et al., 2022). Ports in the Pacific Islands, Caribbean Sea, and Indian Ocean could be under the highest levels of risk from tropical cyclones, coastal flooding, and extreme temperatures by 2100 (Izaguirre et al., 2021). Around 100 airports in the world could fall below sea level, causing major annual disruptions to air routes (Yesudian & Dawson, 2021). Air operations will likely be affected by extreme temperatures, wind pattern changes, more clear air turbulence, and increased occurrence of extreme weather events, requiring longer take-off distances and increasing delays. Extreme temperatures and precipitation will accelerate pavement deterioration and increase the occurrence of road landslides due to soil saturation, significantly rising costs for maintenance and rehabilitation agencies (Qiao et al., 2022). In large cities, river flooding could cost more than USD 194 billion per year and affect more than 7.4 million people, with LAC cities experiencing the most drastic changes (C40 Cities, 2022). Urban flooding will not only cause more frequent damage and disruptions to the operation of underground public transportation systems, but also greater congestion due to speed reductions. Extreme temperatures will limit the use of active transportation modes and increase their shading needs, while also boosting public transportation systems' operational costs due to higher air conditioning requirements.

This chapter presents future scenarios for the region, reflecting what could happen if no actions are taken at global or regional scales to limit transportation emissions and thus contribute to counteract the effects of CC. In partnership with OECD's ITF, this chapter analyzes the emissions scenario for LAC using estimates from their ITF Transport Outlook 2023. Projections of changes in exposure to hazards exacerbated by CC are from the authors, based on available literature and official documents.

2.1.
“Business as usual”: Transportation sector emission scenarios in LAC

If no action is taken, emissions from the transportation sector will continue to rise in LAC. Based on passenger and freight demand projections, the ITF Transport Outlook 2023 models GHG emissions from the transportation sector and reports them as CO2 equivalent emissions. These emissions are differentiated into Tank to Wheel (TTW) and Well to Tank (WTT) emissions. The former corresponds to direct emissions from vehicle exhaust pipes and the latter to indirect emissions incurred during fuel production, refinement, and transportation. ITF presents two scenarios: Current Ambition and High Ambition (Box 2.1). Under the Current Ambition scenario, which represents the “business as usual” (BAU) scenario, governments are slowly addressing existing and future decarbonization commitments in their institutional and policy agendas, incentivizing technological developments aimed at replacing internal combustion engine (ICE) vehicles, demand management and modal shift measures, and investment in alternative modes to the private vehicle. This scenario will be taken as a baseline for the region’s emissions analysis. A High Ambition scenario assumes that governments adopt accelerated measures to decarbonize transportation, including the provision of alternatives to private motorized vehicles and improvements to public transportation services, walking and cycling, public transportation efficiency, and freight transportation.

BOX 2.1.

Transportation decarbonization and definition of scenarios

The Current Ambition and High Ambition scenarios developed by the ITF correspond to two modeled policy scenarios, representing two levels of ambition for the decarbonization of the transportation sector. The set of modeling tools developed by ITF allows the construction of prospective scenarios of transportation activities, covering all modes of transportation and types of activity (passengers and freight) which, gathered in the same framework, allow the analysis of technological trends in transportation activity and CO2 emissions (ITF, 2023d). Each of the scenarios considers assumptions covering different transportation sector intervention areas (Table 2.1.1). Prospective modeling implies different degrees of progress in the intervention areas for the time horizons (2020s, 2030s and 2040s)[2] and the two analyzed scenarios.

TABLE 2.1.1.

Scenario definition: Transportation sector intervention areas considered in the elaboration of assumptions

Type of specification	Areas of intervention considered in the elaboration of assumptions
Urban passenger demand and mode choice	• Economic instruments: carbon pricing, road pricing and parking charging • Improvements in transportation infrastructure: pedestrian, cycling and public transportation infrastructure • Improvements in transportation services: optimization, incentives for shared mobility, MaaS systems • Regulatory measures: speed limits, parking restrictions, urban vehicle restrictions • Additional measures: land use planning policies, TOD and telecommuting incentives

2 For more details on decarbonization assumptions and scenarios, see ITF Chapters 2 and 3 (2023).

Type of specification	Areas of intervention considered in the elaboration of assumptions
Non-urban passenger demand and mode choice	• Rail investments • Incentives for shared mobility • Carbon pricing policies • Taxes on air tickets • Flight bans
Freight demand and mode choice	• Measures for sustainable urban logistics: cargo bikes and shared ownership • Incentives for high-capacity vehicles • Distance-based charges • Slow and intelligent navigation • Digital transformation strategies • Infrastructure network improvements • Carbon pricing policies • Commodity trading trends (based on fossil fuels and others)
Transition to clean vehicles	• Zero emission vehicle targets • Memoranda of understanding on medium and heavy zero-emission vehicles • Biofuel blending targets • SAF mandates

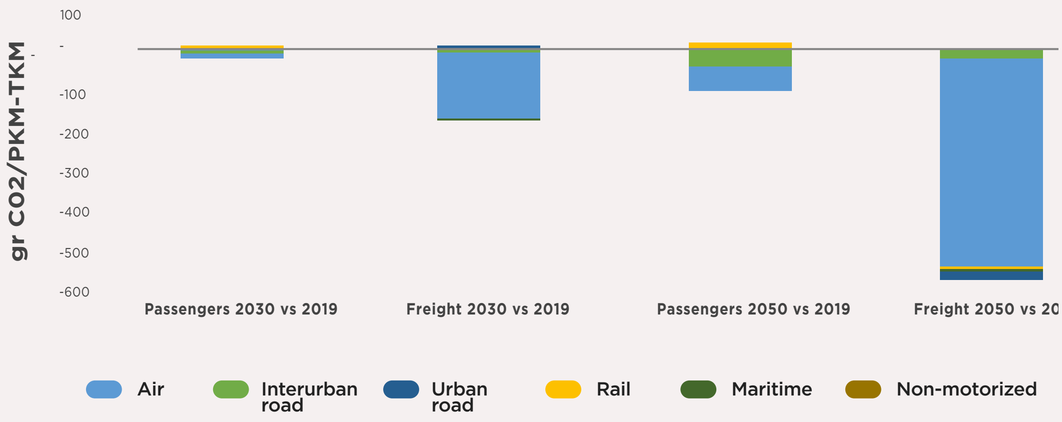
Source: Prepared by the authors based on ITF (2023d).

Note: The assumptions developed in each of the intervention areas considered for the three evaluated time horizons (2020s, 2030s and 2040s) are defined by the two study scenarios (Current Ambition and High Ambition).

According to projections under ITF's Current Ambition scenario for the activity of LAC's transportation sector (ITF, 2023a), total goods transported domestically and internationally will more than double by 2050, reaching 19 trillion tonne-kilometers (TKM). Maritime transportation will see the largest demand increase among transported goods in LAC, reaching 9.4 trillion TKM, followed by interurban road transportation with 6 trillion TKM. Passenger transportation demand will grow by 67% during the same period, reaching 7.6 trillion passenger-kilometers (PKM). Within passenger transportation, interurban road transportation will see the greatest increase in demand and reach 4.3 billion PKM transported, followed by urban road transport with 1.7 billion PKM. Despite this increase in transportation activity, the slow inertial trend in the sector's decarbonization policy will lead to improvements in the efficiency of transportation systems, generating lower emissions per PKM and per TKM transported. This is shown in Figure 2.1.1, where freight transportation (particularly the air mode) will have the greatest achievements.

FIGURE 2.1.1.

Projected CO2 emissions reductions per PKM and TKM for LAC from passenger and freight transportation under the Current Ambition scenario



Source: Calculations based on data provided by ITF (2023a). Figures include TTW and WTT emissions.

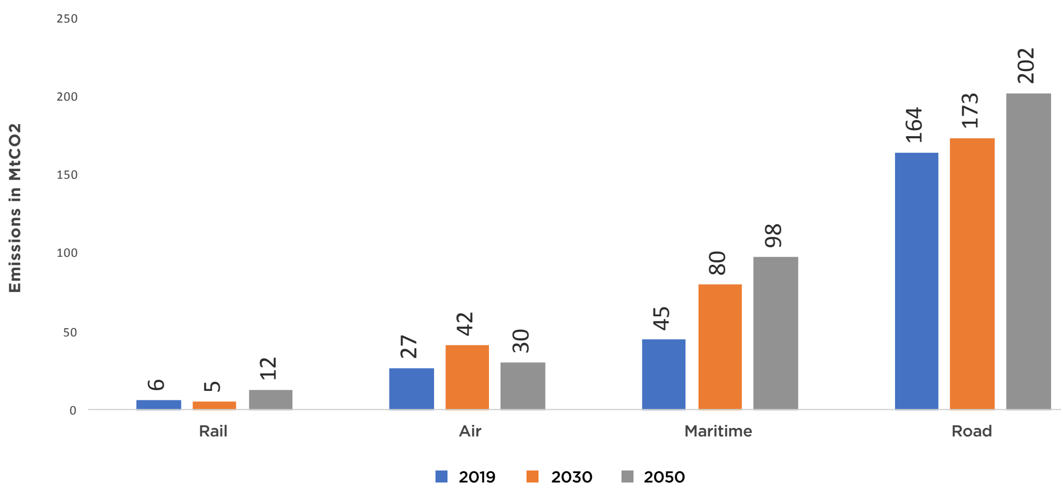
Note: Calculations include international and domestic transportation. The values for freight transportation are expressed as gr CO2/TKM and the values for passenger transportation are expressed as gr CO2/PKM.

In the High Ambition scenario, policies that would leverage improvements in transportation systems efficiency are framed within the “Avoid-Shift-Improve” paradigm. At the urban level, these policies correspond to economic instruments, infrastructure and service improvements, and regulatory measures to restrict the use of private vehicles and promote public transportation through land use policies. Regarding interurban passenger transportation, policies are focused on rail infrastructure investments, carbon and airfare taxes, and bans on short-haul flights. For freight transportation, at the urban level governments implement sustainable urban logistics plans, while at the non-urban level they implement strategies to reduce the intensity of fossil fuel use and encourage digital transformation strategies. Concerning the transition to zero- and low-emission vehicle fleets, governments enact policies to encourage the replacement of internal combustion vehicles with zero- and low-emission vehicles, as well as innovation in sustainable energy sources. For more details on the policies underpinning these scenarios, refer to ITF (2023d).

Looking at interurban freight transportation emissions in LAC under the Current Ambition scenario, the emissions value corresponding to road transportation would grow by around 23%, as a result of an estimated 80% increase in transported freight. In this way, road transportation would become responsible for 60% of interurban freight transportation CO2 emissions by 2050. Maritime and rail transportation would experience the largest percentage increases in emissions by 2050, growing in the order of 118% and 96% due to a 176% increase in their freight operations. Meanwhile, air transportation would decrease its share of total emissions in 2050, as a result of implementing clean fuels regulations, which would translate into efficiencies of 40% in terms of reduced CO2 emissions per transported TKM (Figure 2.1).

FIGURE 2.1.

Interurban freight transportation CO2 emissions projected for LAC under the Current Ambition scenario

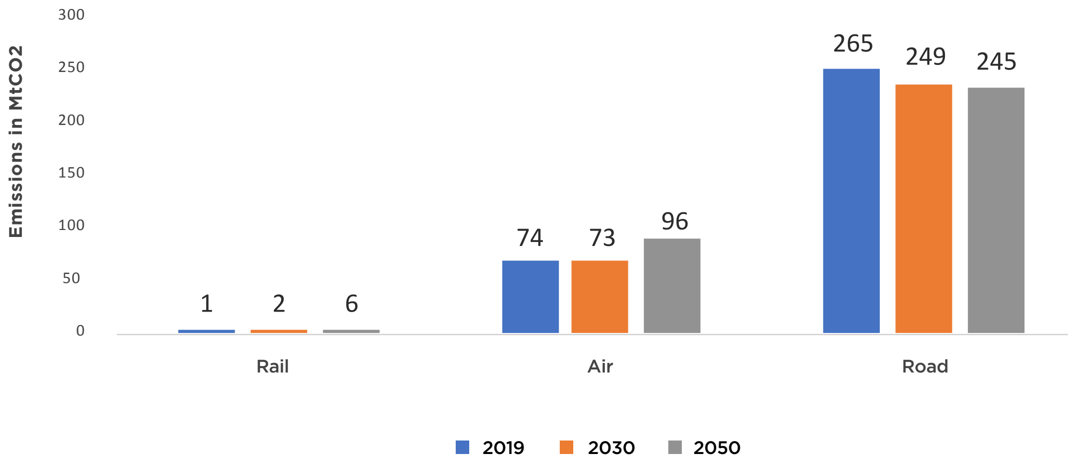


Source: Calculations based on data provided by ITF (2023a). Figures include TTW and WTT emissions.

As for LAC's interurban passenger transportation, the largest number of emissions under the Current Ambition scenario would come from road transportation. Despite achieving an 8% reduction in emissions by 2050 due to an efficiency increase of around 46% in terms of reduced CO2 emissions per transported PKM, road transportation would still concentrate 71% of total emissions of the subsector. It would be followed by air transportation, which would experience a 30% increase by 2050 (Figure 2.2).

FIGURE 2.2.

Interurban passenger transportation CO2 emissions projected for LAC under the Current Ambition scenario

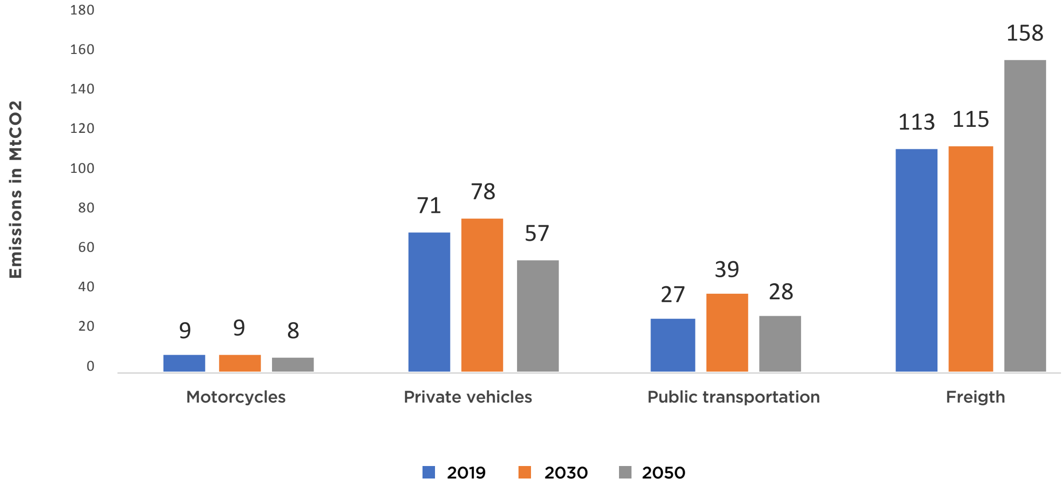


Source: Calculations based on data provided by ITF (2023a). Figures include TTW and WTT emissions.

At the urban level, according to the inertial policy scenario, freight transportation would be the largest CO2 emitter, with a 40% increase between 2019 and 2050, consistent with a 68% rise in transported urban freight. Private vehicles would be responsible for 23% of urban transportation CO2 emissions, reducing their emissions by 20% compared to 2019 and improving their efficiency by 38% measured in CO2 emissions per transported PKM. Public transportation would manage to improve its efficiency in a similar order to private vehicles, around 34%, increasing its emissions by 6% but meeting 60% more demand. In turn, motorcycles would reduce their contribution to CO2 emissions due to the implementation of policies discouraging their use and the greater ease for their electrification (Figure 2.3).

FIGURE 2.3.

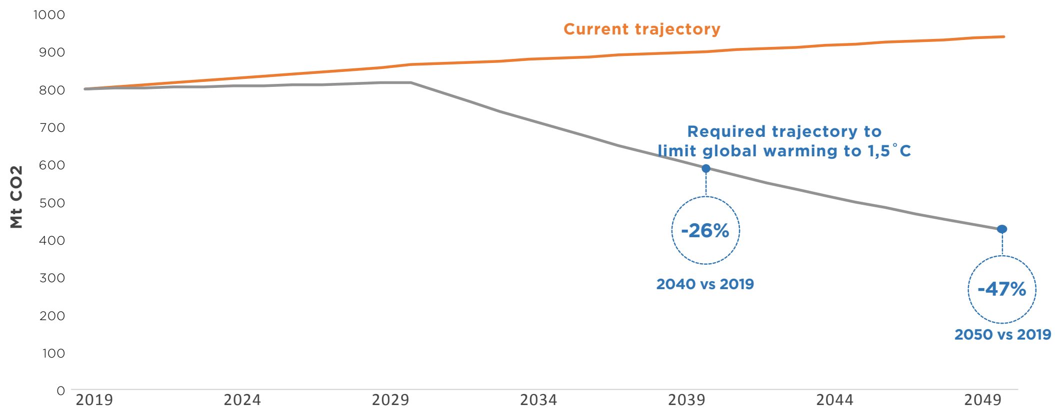
Urban transportation CO2 emissions projected for LAC under the Current Ambition scenario



Source: Calculations based on data provided by ITF (2023a). Figures include TTW and WTT emissions.
Note: Public transportation includes bus and rail. Motorcycle refers to two- and three-wheeled vehicles.

Given the above, emission projections linked to the BAU scenario show that, by 2050, transportation in LAC would emit 940 MtCO2, corresponding to a 17% increase over 2019 levels. Without stronger and more ambitious policy intervention, the sector's CO2 emissions will grow rapidly, consistent with the growing travel demand projected for LAC (Box 2.1). Conversely, under a scenario in which ambitious decarbonization policies are implemented, the emission reduction goal could be achieved, meeting the Paris Agreement objectives by 2050 (ITF High Ambition scenario). According to this target, emissions should be 589 MtCO2 by 2040 (26% reduction from 2019 levels) and 424 MtCO2 by 2050 (47% reduction from 2019 levels) (Figure 2.4).

FIGURE 2.4. Evolution of CO2 emissions under two policy scenarios in LAC



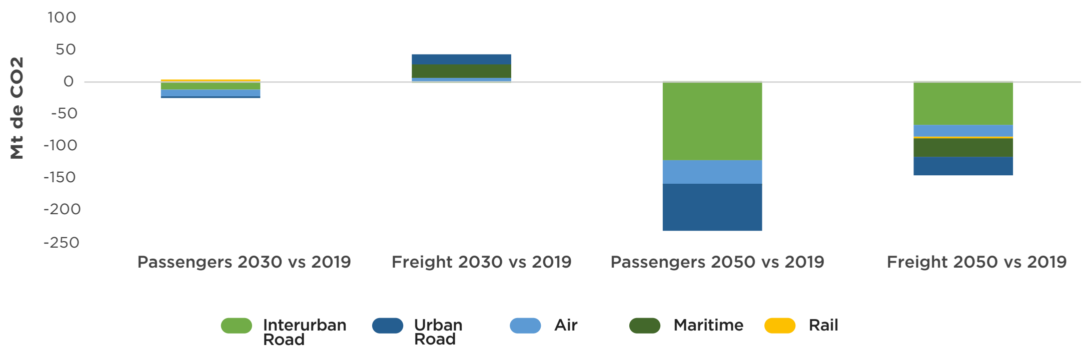
Source: Prepared by the authors based on data from ITF (2023a).

Note: Projected scenarios for LAC were calculated based on the percentage reductions in emissions estimated by ITF (2023a) under the Current Ambition and High ambition scenarios supporting the SDGs. Target percentage reductions in emissions to limit global warming to 1.5 C are shown for years 2040 and 2050.

Road transportation requires the most attention. Under the emissions scenario consistent with limiting global warming to 1.5°C (ITF High Ambition scenario), road transportation should achieve a total reduction of 288 MtCO2 (-45% compared to 2019 levels) by 2050. Of this, passenger transportation should contribute with a reduction of 194 MtCO2 (67% of the total road transportation reduction) while freight transportation should contribute with a reduction of 94 MtCO2 (33% of the total road transportation reduction) (Figure 2.5). On the other hand, emissions from air transportation should be reduced by 56% and those from rail transportation by 40% compared to 2019 levels.

FIGURE 2.5.

Required reduction in LAC's transportation CO2 emissions to achieve objectives of the Paris Agreement under the High Ambition scenario



Source: Prepared by the authors based on data from ITF (2023a).

2.2. CC challenges for transportation in LAC

Greater frequency and intensity of extreme hydrometeorological events, coupled with expected long- term changes in average variables such as temperature, precipitation and sea level, will affect the transportation sector (IPCC, 2022; Lempert et al., 2021). These changes will expose the infrastructure to climate hazards of greater intensity than those considered in the design, with potential consequences in failures and disruptions for the sector. Although there is uncertainty about the magnitude of the changes of each meteorological variable, it is possible to generate scenarios to analyze the possible future impacts of CC and prioritize adaptation measures. The Intergovernmental Panel on Climate Change (IPCC) has developed multiple sets of scenarios for this purpose. Most notable in the literature is the use of Representative Concentration Trajectories (RCP) scenarios, which were defined as part of IPCC's fifth assessment report. These scenarios summarize a series of possible futures of atmospheric GHG concentrations and radioactive forcing levels associated with different increases in the average temperature of the Earth with respect to pre-industrial levels (IPCC, 2014b). Additionally, in the sixth assessment report of the IPCC, a new set of scenarios called Shared Socioeconomic Trajectories (SSP) was introduced.

A regional analysis of CC exposure was developed for air, maritime and road transportation.

The most widely used scenario in the literature to evaluate the possible negative impacts of CC on the transportation sector is RCP8.5, as it is the most critical in terms of physical impacts. In the evaluation of possible negative impacts of CC on transportation infrastructure, the pessimistic scenario of very high GHG concentrations called RCP8.5 is frequently used, in which the average surface temperature reaches an increase of 5°C by 2100 with respect to pre-industrial levels. Given their recent introduction, SSP scenarios have not yet been used as widely as RCPs in the literature on possible future impacts of CC on transportation systems. However, there are equivalences between the SSP and RCP scenarios, such that the SSP5-8.5 scenario corresponds to a scenario of high dependence on fossil fuels, which would generate GHG concentrations in the atmosphere equivalent to those assumed in the RCP8.5 scenario.

Estimating the physical and economic impacts of future emissions concentration scenarios on transportation requires climate models. The most commonly used are General Circulation Models (GCMs). These models represent the physical phenomena occurring in the climate system by means of mathematical equations and thus obtain future projections of hydrometeorological variables associated with a given scenario at the global level. The resolution of the results generated by GCMs varies between 100 and 500 km, so it is generally necessary to carry out a process of bias correction and spatial disaggregation on the results of GCMs to obtain higher resolution projections that allow evaluating possible impacts at the local level.

Not all LAC countries and infrastructures are equally exposed to climate hazards or have the same level of sensitivity. Having a reference framework at the regional level allows us to understand these asymmetries and develop actions focused on the most exposed assets. In this sense, a regional analysis of exposure to CC was developed, focused on the variables that will most directly impact air, maritime and road infrastructure. In the case of air and maritime infrastructure, projected sea level rise was analyzed in relation to the current location and elevation of coastal airports and seaports in the region. The above, considering the relevance of airports and seaports in LAC for the movement of millions of dollars in freight and thousands of passengers, as well as the need to identify those airports and ports that could suffer temporary or permanent flooding and limitations to their operations. On the other hand, in the case of road transportation, exposure to changes in extreme temperatures and extreme rainfall was analyzed, as these are the variables behind the accelerated deterioration of pavements and the occurrence of landslides due to soil saturation. The analysis specifications are summarized in Table 2.1, followed by the results obtained for air, maritime, and road infrastructure.

TABLE 2.1. **Sources of information used in the regional exposure analysis**

Mode	Infrastructure inventory	Terrain elevation	Climate Projections				
			Variable(s)	Scenario	Base period	Future period	Source
Air	World Bank[1]	NASA's ICESAT2 satellite[4]	Mean sea level rise	SSP5-8.5	2014	2100	IPCC AR6[5]
Maritime	World Port Index[2]						
Road	OpenStreetMap[3]	N/A	Change in temperature and precipitation extremes (TX35 and RX5)	RCP 8.5	1995-2014	2041-2060	CORDEX models ensemble[6]

Source:

1. Airport location taken from the Global Airport Database of the World Bank (2020).
2. Seaports location taken from the World Port Index (National Geospatial Intelligence Agency, 2019).
3. Primary, secondary, and tertiary road networks for each country taken from OpenStreetMap (Geofabrik, 2023).
4. Airport and seaport elevations were calculated using a global elevation database for low-lying coastal areas (Vernimmen & Hooijer, 2022), which was generated using LiDAR data produced by the ICESAT2 satellite and validated for coastal flood analysis (Hooijer & Vernimmen, 2021; Vernimmen & Hooijer, 2023).
5. Projections of sea level rise (Garner et al., 2021; Kopp et al., 2023) correspond to the sixth assessment report of the IPCC (Fox- Kemper et al., 2021).
6. Projections of change in the number of days per year under temperatures above 35°C (TX35) and projections of change in maximum accumulated precipitation during five consecutive days (RX5) come from the CORDEX model ensembles for North, Central and South America available in the IPCC interactive atlas (J. M. Gutiérrez et al., 2021; Iturbide et al., 2021). The CORDEX projections are based on general circulation climate models, and also include a dynamic spatial disaggregation process to obtain estimates at a resolution of 50km.

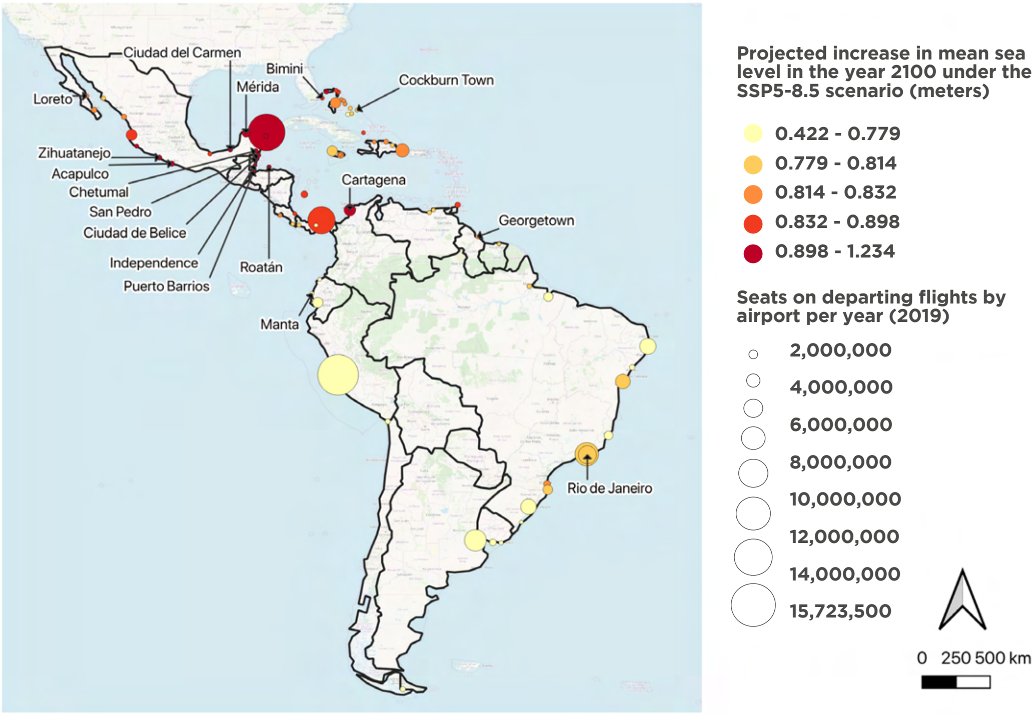
Some of the airports most affected by sea level rise offer key services for tourism and connectivity.

In air transportation, airports exposure to sea level rise could affect tourism activities and the connectivity of certain areas. The air sector analysis consisted of identifying those airports that, given their current elevation and projected mean sea level rise, could suffer flooding that would prevent their operation by the end of the century under the SSP5-8.5 scenario. The results (Figure 2.6) indicate that some airports in the region could experience increases in mean sea level of more than one meter by 2100. This is the case for the airports of Cartagena (Colombia), Puerto Barrios (Guatemala), Roatán Island (Honduras), Belize City (Belize), San Pedro (Belize), Independence (Belize), Zihuatanejo (Mexico), Acapulco (Mexico), Mérida (Mexico), and Chetumal (Mexico). When comparing projected sea level rise with current elevation data, airports with a lower relative elevation towards 2100 are Santos Dumont in Rio de Janeiro (Brazil), Manta (Ecuador), Georgetown (Guyana), Cartagena (Colombia), Cockburn Town (The Bahamas), Bimini (The Bahamas), San Pedro (Belize), Belize City municipal airport (Belize), Ciudad del Carmen (Mexico), and Loreto (Mexico).

Some of the airports that are projected to be most affected by mean sea level rise offer key services for tourism and connectivity. For example, Cartagena's Rafael Núñez International Airport absorbs 6% of international passengers and 8% of domestic passengers who move annually by air in Colombia (Aeronáutica Civil, 2021). Disruptions in the operation of this airport would also have significant consequences on the labor and productive market of Cartagena, since the tourism sector generates 10.4% of jobs in the city and 4.4% of the GDP of the department of Bolívar (DANE, 2021; ICULTUR, 2020). Another example is the case of The Bahamas, where tourism generates 27% of total direct jobs and an additional 25% in indirect jobs (Granda et al., 2022). Airports that could be affected by projected sea level rise in The Bahamas cover national and international routes, essential for tourism and the transportation of passengers and goods between islands. Potential disruptions to Belize's airports would also have significant impacts on the country's tourism and connectivity. The above, taking into account that 33% of Belize's GDP is related to air transportation and the entry of international tourists through this mode (Oxford Economics, 2018), and that this country concentrates around 13% of domestic air traffic in the Caribbean (Briceño-Garmendia et al., 2015).

FIGURE 2.6.

Projected mean sea level rise by 2100 under SSP5-P8.5 for coastal airports in the region located 10 meters or less above sea level



Source: Prepared by the authors with data from the World Bank's global airport database for the location of airports (World Bank, 2020), data from the ICE-SAT2 satellite for the calculation of airport elevation (Vernimmen & Hooijer, 2022), sea level projections from the sixth IPCC assessment report (Fox-Kemper et al., 2021; Garner et al., 2021; Kopp et al., 2023), and number of seats on departing flights per airport per year for 2019 obtained from OAG (OAG, 2019).

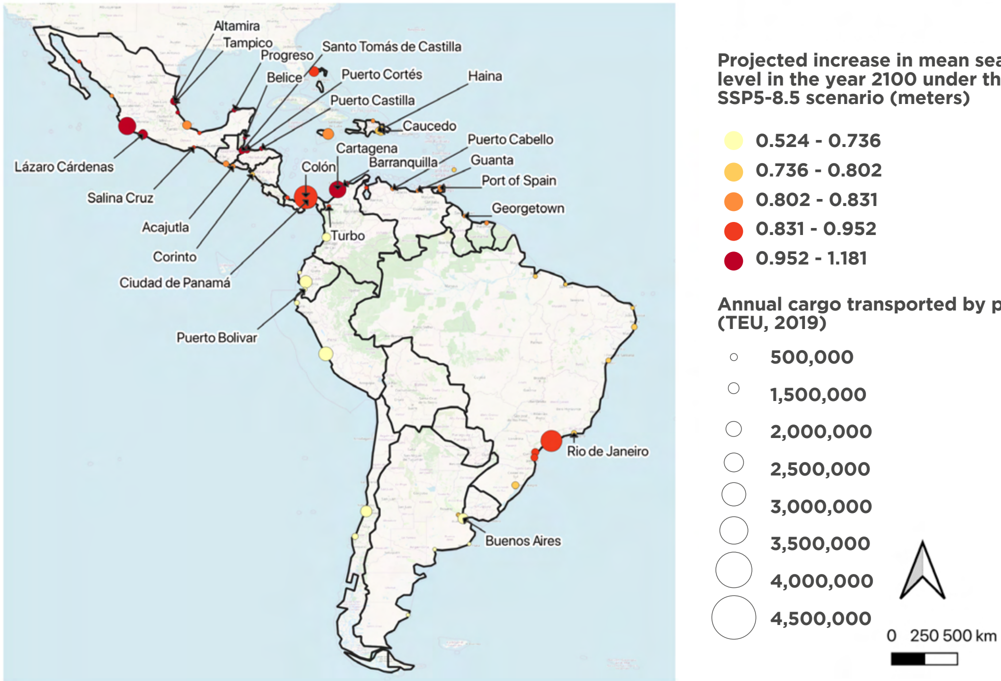
Note: Only airports located at a current elevation of 10 m or less above mean sea level are plotted. The color of the circles shows projected sea level rise towards 2100 compared to mean sea level for the period 1995-2014, while the size of the circles indicates the number of seats offered on departing flights from each airport during 2019.

CC can have a significant impact on market access through maritime transport. The seaports of Cartagena (Colombia), Barranquilla (Colombia), Puerto Castilla (Honduras), Puerto Cortés (Honduras), Santo Tomás de Castilla (Guatemala), Belize City (Belize), Progreso (Mexico), Tampico (Mexico), Altamira (Mexico), and Lázaro Cárdenas (Mexico) could experience mean sea level rise values of more than one meter by 2100 (Figure 2.7). Although not all these ports have a current elevation of less than one meter, it is important to consider the implementation of adaptation measures given their relevance for international trade, especially since mean sea level rise will also affect the magnitude and frequency of extreme events. The need to evaluate potential adaptation measures in the port of Cartagena, one of the main ports in terms of transshipments in LAC, which moves 5.8% of freight transportation in TEUs in the region, stands out (Calatayud & Montes, 2021). Also noteworthy are Puerto Cortés, the most important port in Honduras that participates in more than 15% of Central American maritime transportation routes (Matiz et al., 2022), and Lázaro Cárdenas, one of the main Mexican ports and the main competitor of the port of Manzanillo (Connell et al., 2015).

Comparing projected sea level rise with current elevation, 19 ports in the region carrying 12.8 million tonnes in 2019 could experience flooding by 2100. These include the ports of Buenos Aires (Argentina), Rio de Janeiro (Brazil), Puerto Bolívar (Ecuador), Georgetown (Guyana), Port of Spain (Trinidad and Tobago), Guanta (Venezuela), Puerto Cabello (Venezuela), Turbo (Colombia), Caucedo (Dominican Republic), Haina (Dominican Republic), Balboa (Panama), Colón (Panama), Corinto (Nicaragua), Acajutla (El Salvador), Puerto Castilla (Honduras), Santo Tomás de Castilla (Guatemala), Belize City (Belize), Salina Cruz (Mexico) and Tampico (Mexico). Among these, Panama's ports stand out, given their relevance to the region and the amount of freight transported (Box 2.2).

FIGURE 2.7.

Projected mean sea level rise by 2100 under SSP5-8.5 for the region's seaports located 10 meters or less above sea level



Source: Prepared by the authors with data from the World Port Index for the location of ports (National Geospatial Intelligence Agency, 2019), data from the ICE-SAT2 satellite for the calculation of port elevation (Vernimmen & Hooijer, 2022), sea level projections from IPCC's sixth assessment report (Fox-Kemper et al., 2021; Garner et al., 2021; Kopp et al., 2023), and container movement data by port from ECLAC (ECLAC, 2019).

Note: Only seaports with a current elevation of 10m or less above mean sea level are plotted. The color of the circles shows the projected sea level rise towards 2100 compared to mean sea level for the period 1995-2014, while the size of the circles indicates the amount of freight transported by each port (in TEU). The map includes the names of ports with sea level rise projections of more than one meter, and those of ports that would suffer the greatest impact when comparing the current elevation with projected sea level rise towards the end of the century.

BOX 2.2.

Impact of sea level rise on Panama's ports

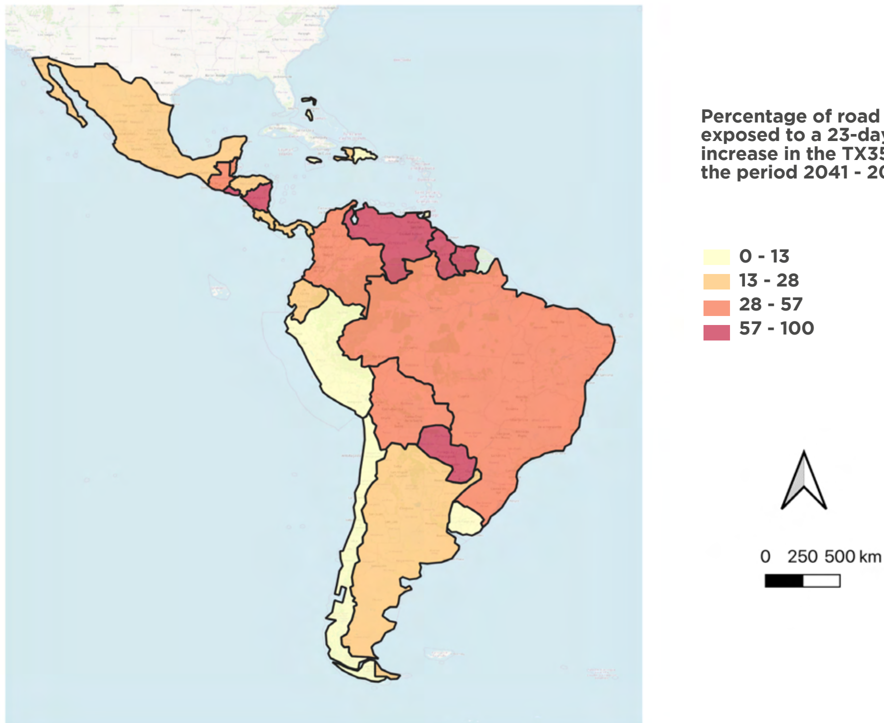
Panama's ports play a leading role in the region and in the international maritime network. Panamanian ports concentrate 14.3% of total container movements in LAC, being surpassed in the region only by the ports of Brazil (Calatayud & Montes, 2021). The port of Colón is the port with the highest maritime activity in the entire region, transporting approximately 4.4 million TEUs in 2019 (ECLAC, 2020b). Being located on both sides of the Panama Canal, the ports of Colón and Balboa become key nodes for the transshipment of containers between global East- West and North-South maritime routes, operating as hubs for the region. Thus, transshipments represent 87% and 89.7% of movements in the ports of Colón and Balboa, respectively (Calatayud & Montes, 2021).

Future sea level rise could have significant negative impacts on the economy of Panama and the region. Towards the end of the century and under the pessimistic RCP8.5 scenario, the IPCC projects sea level rise values of more than 0.8 meters for the Colón and Balboa ports. Given the current elevation of these ports, these sea level rise projections could result in flooding and affect operations. This phenomenon could further worsen depending on local land subsidence and the occurrence of extreme events. According to World Trade Organization statistics, the seaport transportation sector represents 32% of Panama's GDP. Consequently, nearly one third of the country's GDP could be affected, with major consequences for maritime connectivity in LAC given the role of both ports as regional hubs.

The percentage of road network exposed to more frequent extreme temperatures will be higher for small countries in the region. Estimating the temperature ranges to which the region's roads will be subjected is important because extreme temperatures accelerate the deterioration of asphalt pavements. In this sense, and in order to analyze the relative exposure of different countries to extreme temperatures, the percentage of road network that would be exposed to very high increases in the TX35 variable was calculated for each country under the RCP8.5 scenario. The TX35 variable corresponds to the number of days per year with maximum temperatures above 35°C. Given the shorter lifespan of roads compared to the airports and ports analyzed above, projections were used for the medium term (range 2041-2050). Figure 2.8 shows the results of the analysis. In the countries in red – El Salvador, Nicaragua, Venezuela, Guyana, Suriname, and Paraguay – more than 57% of the road network could experience very high increases in the number of days per year with extreme temperatures. The very high increases correspond to those within the 70th percentile of the projections for the region, equivalent to 23 days or more per year under extreme temperatures.

FIGURE 2.8.

Countries from the region classified by the percentage of road network exposed to very high increases in the number of days per year with temperatures above 35°C for 2050 under RCP 8.5



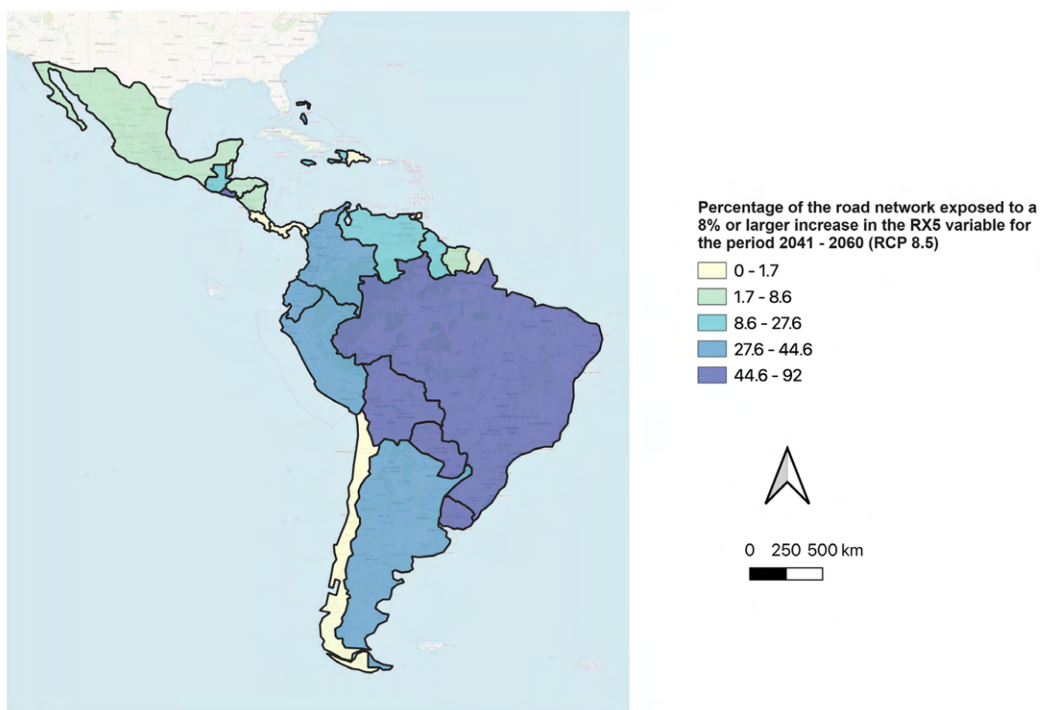
Source: Prepared by the authors

Note: Characterization of the primary, secondary and tertiary road networks from OpenStreetMap (Geofabrik, 2023). Projections of change in the TX35 variable between the periods 1995-2014 and 2041-2060 come from the CORDEX data available in the IPCCC Interactive Atlas (Gutiérrez et al., 2021; Iturbide et al., 2021). The TX35 variable corresponds to the number of days per year with maximum temperatures above 35°C.

Extreme rainfall will pose a major threat to the road network, especially in Southern Cone countries. The variable analyzed in this case was the maximum accumulated precipitation for five consecutive days (RX5), which is relevant for road transportation because it is related to soil saturation and consequent landslides and floods. In this sense, and in order to analyze the relative exposure of different countries to increases in extreme rainfall, the percentage of the road network that would be exposed to very high increases in the RX5 variable was calculated for each country under the RCP8.5 scenario. Given the shorter lifespan of roads compared to the airports and ports analyzed above, projections were used for the medium term (range 2041-2050). The tertiary network was included in the analysis, as unpaved roads may be more vulnerable under extreme rainfall. The results (Figure 2.9) show increased exposure for El Salvador, Brazil, Bolivia, Paraguay, and Uruguay, where more than 45% of the road network is projected to experience very high increases in maximum accumulated precipitation over five consecutive days. Very high increases are defined as those within the 70th percentile of the projections for the region, equivalent to an increase of 8% or more on maximum precipitation accumulated over five consecutive days.

FIGURE 2.9.

Countries from the region classified by the percentage of road network exposed to very high increases in maximum accumulated precipitation during 5 consecutive days for 2050 under RCP 8.5



Source: Prepared by the authors.

Note: Characterization of the primary, secondary and tertiary road networks from OpenStreetMap (Geofabrik, 2023). Projections of percentage change in the RX5 variable between the periods 1995-2014 and 2041-2060 come from CORDEX data available in the IPCCC Interactive Atlas (Gutiérrez et al., 2021; Iturbide et al., 2021). The variable RX5 corresponds to the maximum accumulated precipitation during five consecutive days.

Recent studies provide a more detailed account of CC hazards for specific infrastructures and geographical areas. The Ministry of Public Works and Communications of the Dominican Republic and the IDB developed a methodology to prioritize investments in the country's road infrastructure based on resilience and robustness criteria, considering CC scenarios (Deltares, 2020; Olaya González et al., 2022). The study employed climate projections from specific CGMs that conform to local historical data and estimated that, in a high-GHG emission CC scenario, projected increases in precipitation would result in significant decreases in the return period of road network flooding. Thus, extreme flood events that currently have a return period of 100 years could have a return period of 41 years by 2050. It is estimated that annual damage to the road network due to river flooding could increase by up to 144% by 2050 in the CC scenario of high GHG emissions, reaching a value of USD 2.7 million/year. Losses associated with disruptions to road network operation generated by river flooding could reach USD 38.8 million/year by 2050, not only considering the change in the flood return period under a CC scenario of high GHG emissions, but also the projected increase in traffic towards 2050.

Identifying the countries of the region where the greatest increases in extreme temperatures and precipitation are projected is a starting point for more detailed analyses. The regional analysis for roads presented above allows estimating the relative exposure of different countries using the same methodology, and identifying countries where the largest increases are projected. However, identifying, prioritizing and proposing adaptation measures at project level requires more detailed analyses using the climate models that best represent local climatology. In line with this need, Box 2.3 presents the results of a more detailed analysis of exposure to extreme temperatures conducted for the road network of El Salvador, one of the countries with the highest percentages of road network exposed to CC hazards, according to the regional analysis for roads described above.

BOX 2.3.

Exposure of El Salvador's road network to extreme temperatures

El Salvador is one of the countries in the region with the greatest projected increases in the levels of exposure of road infrastructure to extreme temperatures. To analyze possible future scenarios in greater detail, an additional analysis was performed using climate models recommended specifically for the country and projections with higher resolution than those used in the regional analysis. The GCMs selected for this detailed analysis were MRI-CGCM3, HadGEM2-AO, MIROC5, GFDL-CM3, CSIRO-Mk3-6-0, and CSIRO-Mk3-6-0, which correspond to a more recent version of the models used in El Salvador's third national communication (MARN, 2018)[3]. The processing used to move from the results of these models to projections with higher resolution was performed by NASA as part of the NEX-GDDP- CMIP6 initiative (NASA, 2021), using a Bias Correction and Spatial Disaggregation Method (BCSD). The results of this spatial disaggregation process have a resolution of 25km and are calibrated to local data. Additionally, it was possible to differentiate paved and unpaved road sections, according to information provided by the Ministry of Public Works and Transport. The information on paved and unpaved sections allowed us to evaluate the most relevant variables for each type of infrastructure, since extreme temperatures will mainly affect paved roads.

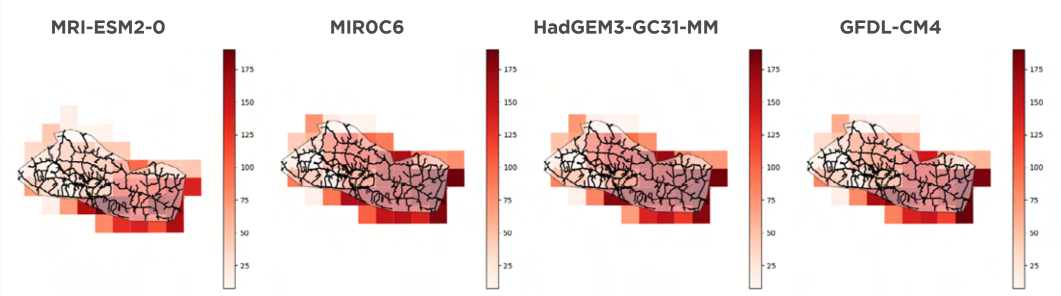
The spatial distribution of projected change in extreme temperatures within the country allowed identifying paved road sections that could require the development of adaptation measures. To obtain this spatial distribution, the maximum daily temperature data (tasmax) reported by NASA for El Salvador was processed to obtain the average number of days per year with maximum temperatures above 35°C for each model for the base (1995-2014) and future (2041-2060) periods. This

3 The analysis is based on the most recent versions (CMIP6) of the models used in the third national CC communication of El Salvador (which corresponded to CMIP5). The CSIRO models are excluded for not being available in the CMIP6 NASA database.

information was overlaid with the layer of paved roads to identify the roads that would be exposed to the greatest increases in TX35. The four analyzed models project very similar spatial patterns for changes in temperature extremes, as shown in Figure 2.3.1. This agreement between spatial trends projected by four different models allows concluding that the southwestern part of the country will probably concentrate the largest increases in the number of days per year under extreme temperatures. Additionally, Figure 2.3.2 indicates that the sections with higher levels of exposure to extreme temperatures in the base period could also experience the largest increases in the TX35 variable towards mid-century.

FIGURE 2.3.1.

Projected TX35 increments for El Salvador under scenario SSP5-8.5, and paved road network

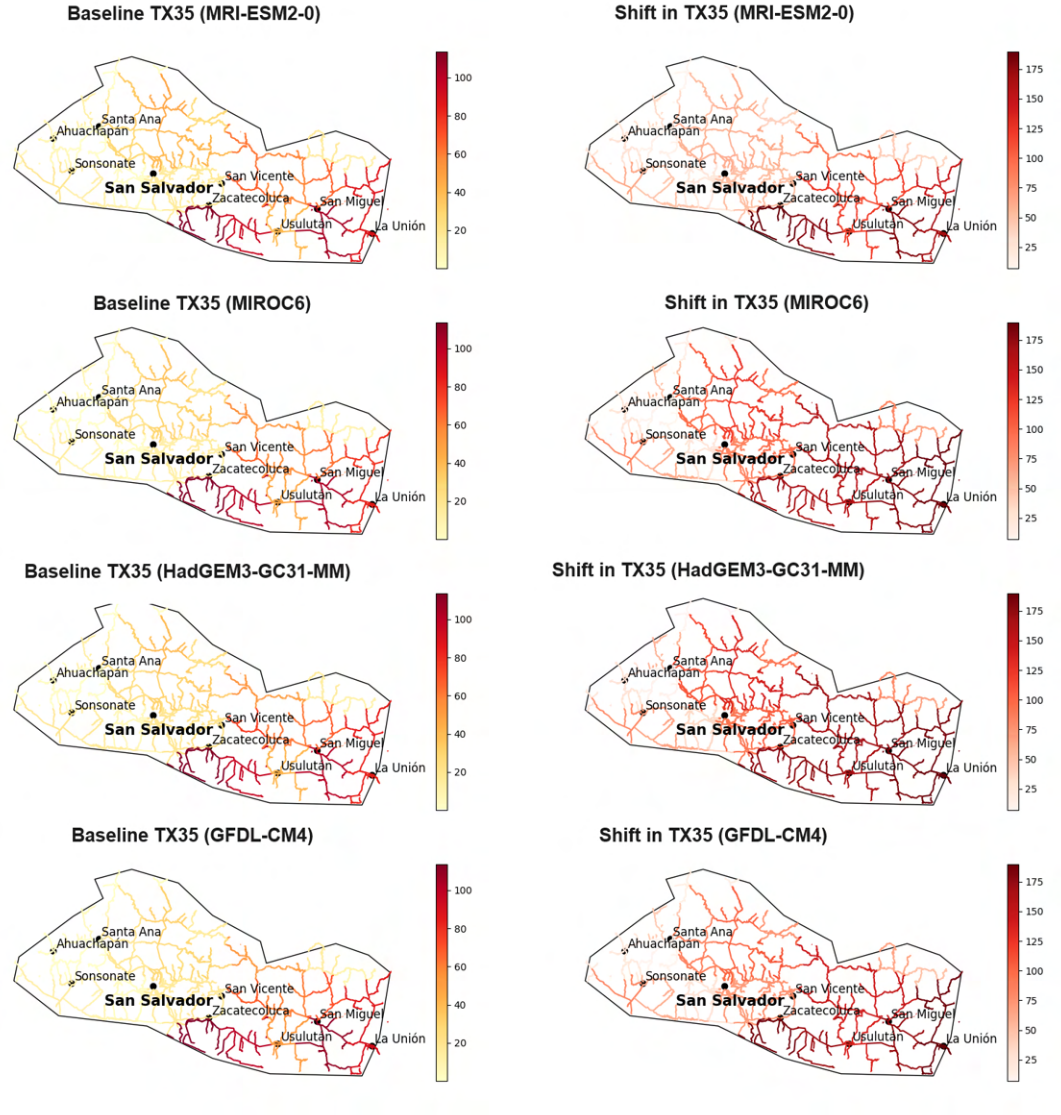


Source: Prepared by the authors with NASA projections (NASA, 2021).

Note: The TX35 variable corresponds to the number of days per year with maximum temperatures above 35°C. The graphed values correspond to projections of change in the TX35 variable from four different models between the base (1995-2014) and future (2041-2060) periods. The paved road network is graphed in black.

FIGURE 2.3.2.

Exposure of El Salvador's paved road network to TX35 in the base period and change in the exposure of the paved road network between the base period and mid-century under the SSP5-8.5 scenario



Source: Prepared by the authors with NASA projections (NASA, 2021).

Note: The TX35 variable corresponds to the number of days per year with maximum temperatures above 35°C. The base period is between 1995 and 2014. The future period is between 2041 and 2060.

By mid-century, between 17% and 56% of El Salvador's paved road network is projected to experience increases of at least 100 additional days per year under extreme temperatures. The consequences of the projected increase in the frequency of extreme temperatures are related to an accelerated deterioration of paved roads located in the southwestern part of the country, which can result in shorter lifespans for these assets and affect their operating conditions. Due to the accelerated deterioration, it will probably be necessary to increase the frequency of routine and preventive maintenance in sections with higher exposure levels, as well as to evaluate other measures for the construction of new infrastructure in these areas. Some alternatives to consider in the development of new roads include using asphalt mixes with greater resistance to extreme temperatures or introducing nature-based solutions that add vegetation parallel to roads. The use of nature-based solutions would help reduce the temperatures to which pavements will be exposed, but also allow better management of surface runoff caused by extreme rainfall by increasing soil capture, retention, and infiltration capacity.

2.3.
Conclusions of future scenarios

• Failure to take decisive action to decarbonize transportation in LAC will result in a rise in sector emissions of around 17% by 2050 compared to 2019, far from the levels required to achieve the Paris Agreement goal. Indeed, achieving this goal requires reducing transportation emissions by 47% by 2050 compared to 2019.

• Under the current trend, emissions from interurban road freight transportation would grow by around 23% as a result of increased economic activity. At the urban level, freight transportation would be the largest emitter of CO2, with an increase of 40% between 2019 and 2050.

• CC will increase the frequency and intensity of extreme weather events and generate temperature, precipitation, and sea level changes. If no action is taken to reduce the vulnerability of the region's infrastructure, this will have a significant impact on the transportation sector.

• In air transportation, the exposure of airports to sea level rise could affect tourism activities and the very connectivity of certain areas, especially in island countries. In maritime transport, potential sea level rise would affect key ports in the regional shipping network, such as the ports of Panama and Cartagena. It would also impact most of the ports in Central America, with a significant risk to the economic activities of this subregion.

• Road infrastructure in lower-income countries will be particularly exposed to more frequent extreme temperatures, with their consequent impact on investment needs in the face of very limited budgets. For its part, extreme rainfall will be the factor of greatest concern for the road network of South America, where it is projected that more than 45% of the road network in several countries will experience very high increases in the maximum value of accumulated precipitation during five consecutive days.

3.

1.5 degrees: The region's international commitments in the fight against climate change

3.1. Transportation within NDCs of countries from the region | **126**

3.2. Availability of other mechanisms to prioritize the transportation sector in the fight against CC | **141**

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3.
1.5 degrees: The region's international commitments in the fight against climate change

In order to fight against the threat posed by CC to humanity, 196 countries signed the Paris Agreement in 2015 as part of the United Nacons Framework Convention on Climate Change (UNFCCC). This binding agreement brings together the joint efforts of signatory countries to limit global warming to below 2°C – preferably 1.5°C– compared to pre-industrial levels (UNFCCC, 2022). Under this agreement, parties must present Nationally Determined Contributions (NDCs) stating the goals and actions they plan to implement to reduce their GHG emissions.

In addition, the UNFCCC includes several mechanisms for countries to disseminate their CC mitigation and adaptation measures and goals, mainly Long-Term Low-Emission Development Strategies (LT-LEDS), National Adaptation Plans (NAPs), Adaptation Communications (ADCOMs), National Adaptation Programs of Action (NAPAs), and Nationally Appropriate Mitigation Actions (NAMAs). These mechanisms are consistent and related to one another. Hence, for example, the modeling exercises of LT-LEDS offer valuable information about short- and medium-term options and uncertainties, which support the process of establishing NDCs. Meanwhile, NAMAs allow disaggregating national objectives from NDCs down to the sector level, establishing monitoring and verification systems, and facilitating funding for NDC implementation. On the other hand, NAPs define adaptation priorities and sectorial or territorial goals, while ADCOMs are used as instruments to report support needs and specific progress to date in the implementation of adaptation priority actions.

The transportation sector is key to achieving Paris Agreement goals and, consequently, should be considered a priority by countries within the mechanisms set up by the UNFCCC. Making progress towards more sustainable transportation systems supports SDGs by fostering more sustainable cities and communities (SDG 11) and increasing climate action (SDG 13). Optimizing supply chains is directly linked to more responsible consumption and production (SDG 12) and to more resilient and sustainable industries, innovation, and infrastructure (SDG 9). Transportation sector improvements can also boost population health and well-being by reducing the number of injuries and fatalities associated with traffic crashes (SDG 3). However, as will be seen below, LAC countries still have a long way to go in terms of developing the normative framework recommended by UNFCCC to promote more sustainable transportation systems that can serve as catalysts for SDGs.

3.1. Transportation within NDCs of countries from the region

There is great heterogeneity in LAC countries' NDCs in terms of prioritizing the transportation sector to reach Paris Agreement goals. Of the 26 countries analysed in the current report,[4] 19 have included transportation-related measures in their NDCs, considering first- and second-generation NDCs[5] (Figure 3.1). Two countries – Guyana and Trinidad and Tobago – have first-generation NDCs, while the others have second-generation NDCs. The latter can be divided into two groups: (i) new documents that constitute "second NDCs", among which we find Argentina, Suriname, and Uruguay; and (ii) updated versions of the first NDCs for all other LAC countries, updated between 2019 and April 2023.[6] Countries with second-generation NDCs are responsible for 99.4% of

4 Analyzed countries are: Argentina, The Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

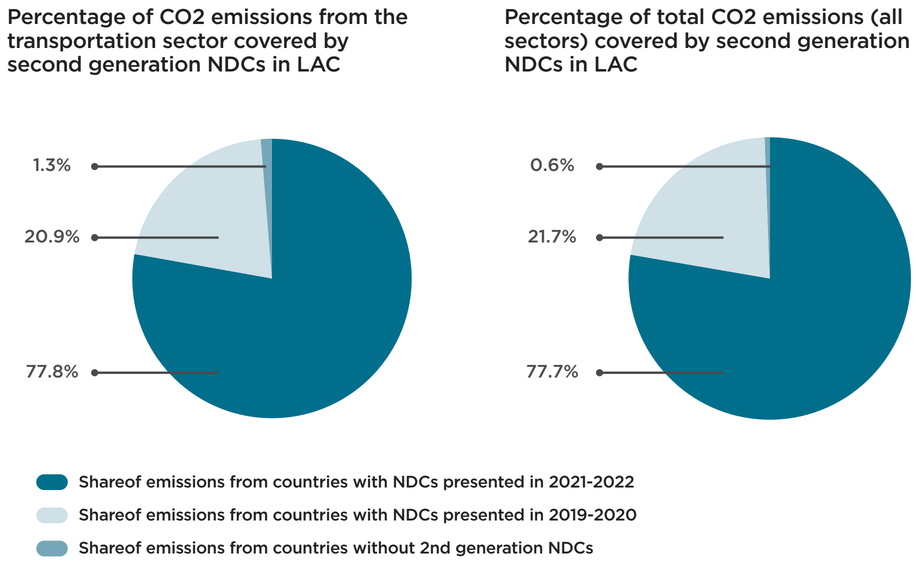
5 Every five years, countries review their NDCs and submit them to UNFCCC, setting progressively higher goals. The second round of updates began in 2020, leading to documents referred to as "second generation" NDCs. Over these five-year cycles, a country can submit a new NDC or make an interim revision to the document.

6 Ecuador did not officially turn its INDCs (Intended Nationally Determined Contributions – the initial document prior to an NDC) – into its first NDC. The country presented its first official NDC in 2019. To the effects of this analysis, we shall consider the INDC as the country's first NDC and the NDC presented as an update to the first NDC.

all LAC transportation emissions (Figure 3.1). Trinidad and Tobago and Belize are the only countries that have set goals to reduce emissions from transportation by 2030 in their NDCs. This figure is proportionally lower than the global mean, given that a total of 23 (16%) of the 140 second-generation NDCs include GHG mitigation goals for the sector (SLOCAT, 2022), compared to one in LAC. In contrast, all countries in the EU –which share a single European NDC- and five Asian countries, have included GHG mitigation goals for the sector (GIZ & SLOCAT, 2022). It is therefore evident that countries in the region generally do not prioritize the transportation sector among the proposed actions to offset CC and, when they do, most of the times the proposed actions are not accompanied by specific sectorial goals to identify their contribution and monitor progress in NDC goal achievement.

FIGURE 3.1.

Percentage of total CO2 emissions and transportation sector's CO2 emissions covered by second- generation NDCs in LAC



Sourcee: Prepared by the authors based on data from IEA (2022).
Note: Graphics do not include The Bahamas, Barbados, and Belize, due to lack of IEA data.

TABLE 3.1. **Mitigation commitments and proposed measures for the transportation sector in LAC NDCs**

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Argentina	Yes	Yes	No		**1.** Urban passenger transport: developing sustainable and low emission mobility (vehicle energy efficiency labeling, promoting buses that run on alternative energy sources, promoting light-duty vehicles with low-emission technologies, renewing bus fleet (Euro 3 to Euro 5), and promoting active mobility). **2.** Prioritizing freight rail: designing a freight rail investment and sustainable transportation plan.	**1.** Improving the efficiency of road freight transport: B-trains and scalable trucks, Smart Transportation Program (including training for drivers), fleet renewal with truck scrapping (National Road Plan for 2025). **2.** Inland waterways freight transport: fleet renewal with alternative energies. **3.** Promoting the use of natural gas and electricity in the transportation sector in general.	Argentina's Second Nationally Determined Contribution (NDC) – 2020, and Argentina's net emissions 2030 target update - 2021.
Bahamas	Yes	Yes	No		**1.** Encouraging the use of public transportation.	**1.** Promoting the electrification of road transportation. **2.** Improving incentives to purchase electric vehicles. **3.** Assessment of government vehicles and program to replace suitable vehicles with electric vehicles. **4.** Introducing electric vehicles into the government fleet. **5.** Installing charging stations for electric vehicles.	The Bahamas Updated NDC – 2022 update

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Barbados	Yes	Yes	No			**1.** As of April 2021, the government's procurement policy is to prioritize purchasing electric or hybrid vehicles. **2.** Barbados Transport Board aims at operating an entirely electric fleet by 2030.	Barbados' first NDC - 2021 update
Belize	Yes	Yes	Yes, (avoid 117 $KtCO_2e$/ year from the transportation sector by 2030)			**1.** Deploying 77 hybrid and electric buses by 2030 (17 by 2025). **2.** Implementing a policy framework to promote more efficient vehicles and alternative fuels/mixes by adding fuel economy labels; emissions tests; fuel economy standards; limitations and taxes/reimbursements based on emissions for imported vehicles by 2025. **3.** Improve passenger electromobility.	Belize's First NDC – 2021 update
Bolivia	Yes	Yes	No			**1.** 10% annual increase in the share of electric vehicles within the public transportation fleet by 2030.	Bolivia's NDC for 2021-2030
Brazil	Yes	No	No				First NDC, second update - 2022
Chile	Yes	Yes	No		**1.** Reducing private motorized transportation and replacing it with buses and bicycles.	**1.** Electromobility in taxis and urban public transportation **2.** Hydrogen-powered transportation.	Chile's first NDC – 2020 update

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Colombia	Yes	Yes	No	**1.** Optimizing logistics.	**1.** Freight mode shift from road to inland waterways – Magdalena River. **2.** Active Transportation and Travel Demand Management (TAnDem). **3.** Rehabilitating the La Dorada - Chiriguana – Santa Marta rail corridor.	**1.** Electric mobility: 600,000 electric vehicles by 2030. **2.** Performance-Based Air Navigation (PBN). **3.** Road Freight Transportation Modernization Program.	Colombia's first NDC – 2020 update
Costa Rica	Yes	Yes	No	**1.** Establishing sustainable logistics models in the country's main ports, urban areas, and logistics consolidation centers. **2.** Reducing the digital and technological gap to increase digital practices such as teleworking, e-commerce, and virtual tourism - which reduce the need to travel. **3.** Promoting policies that allow remote work in government institutions and public and private enterprises.	**1.** Operating the Greater Metropolitan Area Electric Passenger Train, running on renewable electric energy. **2.** Operating the Limon Electric Freight Train (*TELCA*, for its abbreviation in Spanish). **3.** Expanding and improving infrastructure to increase non-motorized mobility by at least 5% (including pedestrian and bicycle mobility). **4.** Encouraging low-emission urban development patterns by integrating the perspective of transit-oriented development in planning and land management instruments.	**1.** Renewing public bus concessions with decarbonization criteria, including division by geographic sectors, electronic payments, and multimodal integration of public and active means of transportation. **2.** Achieving at least 8% in the share of zero emission vehicles within the country's public transportation fleet. **3.** Establishing sustainable logistics models in the country's main ports, urban areas, and logistics consolidation centers **4.** Adopting actions to achieve a zero emission motorcycle fleet and stabilize its growth. **5.** Achieving at least 8% in the share of electric vehicles within the light-duty vehicle fleet (private and institutional). **6.** Implementing the Green Hydrogen strategy for transportation.	Costa Rica's first NDC– 2020 update
Ecuador	Yes	Yes	No		**1.** Efficient public transportation: boosting mass public transportation operated with electric energy (Metro in Quito, Tramway in Cuenca).	**1.** Transportation NAMA: freight and passenger.	Ecuador's first NDC - 2019

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
El Salvador	Yes	Yes	No		**1.** Mass public transportation, bicycle use, walking, restricted speed and traffic management zones, in consideration of road safety and the promotion of public spaces.	**1.** Introducing electromobility in the vehicle fleet with primary attention to passenger, public, and private transportation.	El Salvador's first NDC – 2021 update
Guatemala	Yes	Yes	No			**1.** Electromobility and biofuels (program to renovate the private vehicle fleet with more efficient alternatives and program to promote the use of advanced ethanol in gasoline).	Guatemala's first NDC – 2021 update
Guyana	Yes	No	No				Guyana's first NDC - 2016
Haiti	Yes	Yes	No			**1.** Improving motorcycle maintenance and use **2.** Restricting used vehicle imports.	Haiti's first NDC – 2021 update
Honduras	Yes	Yes	No			**1.** Encouraging electromobility.	Honduras' first NDC – 2021 update
Jamaica	Yes	No	No				Jamaica's first NDC – 2020 update
Mexico	Yes	Yes	No	**1.** Encouraging remote work.	**1.** Expanding and rehabilitating the rail network.	**1.** Electromobility. **2.** More efficient vehicles. **3.** Clean transportation programs.	Mexico's NDC – 2022 update

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Nicaragua	Yes	Yes	No		**1.** Improving Managua's public transportation system.		Nicaragua's first NDC – 2020 update
Panama	Yes	Yes	No				Panama's first NDC – 2020 update
Paraguay	Yes	Yes	No			**1.** Increasing substitution of fossil fuels by biofuels (depending on the type of engine, up to 7.5% addition to diesel and 27.5% to gasoline). **2.** Efficient driving in public and freight transportation. **3.** Gradually substituting conventional vehicles with electric and hybrid vehicles. **4.** Employing green hydrogen.	Paraguay's first NDC – 2021 update
Peru	Yes	No	No				Peru's first NDC, 2021-2030 update status report. 2020
Dominican Republic	Yes	Yes	No		**1.** Extending and developing new routes for 42 kilometers of metro stations in Santo Domingo. **2.** Eleven kilometers of new lines in Santo Domingo's cableway powered by electricity. **3.** Adapting networks for cycle paths in main cities and promoting bicycle use for trips of less than 8km.	**1.** Renovating the bus fleet, using more efficient technologies. **2.** Renovating taxis and collective taxis (or *conchos*), using more efficient technologies. **3.** Modernizing the private vehicle fleet with more efficient technologies.	The Dominican Republic's first NDC – 2020 update

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Surinam	Yes	Yes	No		**1.** Redesigning streets to make them more pedestrian friendly.	**1.** Introducing vehicle emission controls by 2027 (public and private vehicles). **2.** Limiting imports of vehicles over 5 years old (public and private vehicles). **3.** Improving the public transportation system (adding segregated bus lanes, bus stations outside the city center, and shuttle buses within the city center).	Suriname's second NDC - 2019
Trinidad and Tobago	Yes	Yes	Yes, (cutting 1.7 Mton CO2eq in the public transportation sector by 2030 – the equivalent of 30% compared to 2013)				Trinidad and Tobago's first NDC - 2018
Uruguay	Yes	Yes	No			**1.** Increasing the number of electric vehicles and fast and ultra-fast charging stations by 2030 (by 2030, 30% of new light passenger vehicles sold should be electric; by 2030, 600 freight hydrogen fuel cell transportation vehicles should be incorporated to the fleet).	Uruguay's second NDC - 2022

Country	Does the country have an NDC?	Does the country's NDC include measures for the transportation sector?	Are there goals to reduce emissions from the transportation sector in the country's NDC?	Transportation sector emission mitigation measures included in the NDC			Source
				Avoid	Shift	Improve	
Venezuela	Yes	Yes	No		**1.** *Plan de la Patria* (2019-2015) **2.** *Sistema Socialista de Transporte José Antonio Anzoátegui* S.A. - TRANZOATEGUI. **3.** Metro Caracas (C.A.) / Line 5. *Plaza Venezuela - Miranda* II.	**1.** Yutong Venezuela Bus Factory, S.A. **2.** Plan to modernize public and private aircraft fleet. **3.** Modernizing and installing new monitoring and control systems for air traffic in Maiquetia Flight Information Region. **4.** Implementing PBN procedures, including RNAV routes and procedures of continuous approach, ascent and descent. **5.** Implementing Air Traffic Flow Management (ATFM) in the international airports with the highest commercial influx and applying the Aviation System Block Upgrade (ASBU) strategy, among others.	First NDC – 2021 update

Sourcee: Prepared by the authors based on UNFCCC (2023).

Mitigation actions in the transportation sector can be categorized according to the Avoid, Shift, and Improve model. "Avoid" refers to the need to improve the transportation system's efficiency by reducing the demand for motorized travel as well as the duration of journeys imposed by current spatial models through better-integrated plans for land use and transport, and through measures linked to traffic management and demand management via prices. "Shift" seeks to improve the efficiency of individual journeys, from more polluting and energy-consuming modes to greener forms, like active and public transportation. "Improve" focuses on vehicle and fuel efficiency, introducing renewable energy sources into the transportation sector (SLOCAT, 2021).

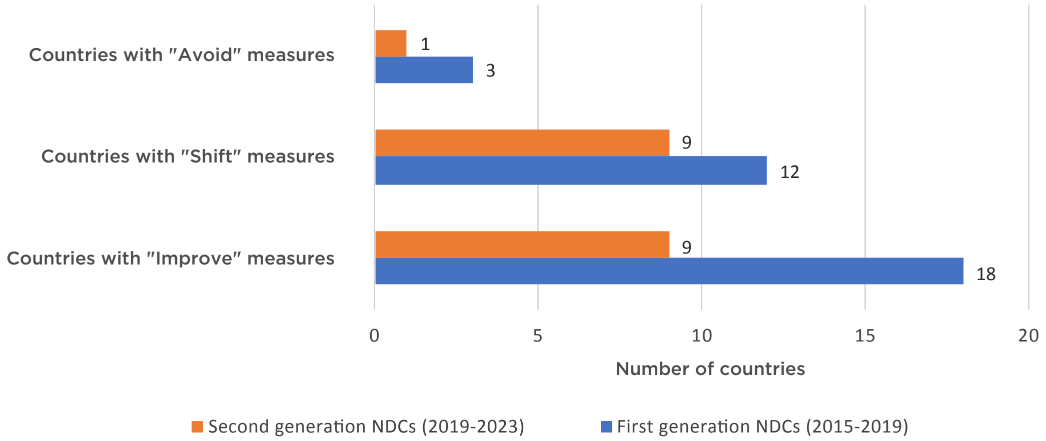
Most mitigation measures included in LAC countries' NDCs fall into the scope of the "Improve" pillar (Figure 3.2). These refer to the promotion of electromobility, especially in public transportation and the taxi fleet, and the incorporation of electric vehicles in the vehicle fleet as well as the infrastructure they require. One third of second-generation NDCs set improvement goals, mainly by increasing the percentage of electric vehicles and of biofuels labeled as sustainable in each subsector.
For example, the Bahamas has set a goal of light electric vehicles to represent 35% of total vehicle sales by 2030. Costa Rica has stated that at least 8% of the light vehicle fleet will be electric by 2030, while in Chile all urban public transportation buses must be electric by 2040. Meanwhile, Suriname is limiting imports of used vehicles that are over five years old, both for public and private use. The same trend can be observed on a global scale: 74 second-generation NDCs (52%) include electric mobility related actions, which represents 19% of all actions (SLOCAT, 2022). This trend is even more noticeable in Asia, where 66% of second-generation NDCs include electrification actions (GIZ & SLOCAT, 2022). Despite freight transportation's contribution to GHG emissions, only a handful of countries have included measures for this segment. Colombia's NDC sets a goal to renovate 57,000 freight vehicles between 2015 and 2030, aiming to reduce 1.03 MtCO2 eq. Uruguay states that by 2030, it will have incorporated 600 hydrogen-cell powered freight vehicles into its fleet, and Argentina has included several measures for road and river freight transportation, such as renewing its fleet and preparing a smart transportation program.

Despite the contribution of freight transportation to GHG emissions, few countries include measures for this segment.

Commitments to improve public transportation systems prevail among actions related with the "Shift" pillar. These actions aim at incentivizing the migration of private car and motorcycle users towards more socio-environmental efficient modes of transportation. They also seek to retain public transportation users by improving quality and making roads more suitable for walking and cycling. In this regard, the Dominican Republic reports the adoption of demand management policies to foster and prioritize the use of public transportation, while the Bahamas mentions measures to enhance service reliability. There are also actions to encourage the use of active transportation -walking and cycling- by extending and improving infrastructure for active modes, promoting public spaces, and adapting existing road networks for bicycle use. For example, Costa Rica has decided to enhance and improve infrastructure by 2030 to achieve an increase of at least 5% in non-motorized mobility compared to current levels. Similarly, El Salvador is promoting the implementation of sustainable modes of transportation such as cycling and walking.

There are hardly any measures related to the "Avoid" pillar in the NDCs. Consequently, current NDCs are not taking full advantage of the framework that, in its entirety, would lead to reducing the sector's GHG emissions much more profoundly (WRI, 2019). The same occurs throughout the world, where less than 10% of second-generation NDCs include measures in the "Avoid" pillar (SLOCAT, 2022). In the region, only Colombia, Costa Rica, and Mexico have included measures in this regard. Colombia is betting on a Transit Oriented Development (TOD) approach to promote access to goods and services at human scale and speed. Costa Rica aims at adopting sustainable models at its main ports, urban areas, and consolidation centers by 2025 in order to boost transportation efficiency. Meanwhile, Mexico is seeking to encourage remote work by developing a joint strategy with industries and authorities, capitalizing on the lessons learned from the COVID-19 pandemic.

FIGURE 3.2. **Summary of LAC's NDC evolution assessment**



Source: Prepared by the authors based on UNFCCC (2023).

Overall, NDCs focus on passenger transportation, paying little attention to freight transportation, one of the region's main sources of emissions. The NDC assessment revels a need to further acknowledge the global efficiency of transportation systems and the fact that the sector's decarbonization requires a systemic transformation. One of the few NDCs that consider switching freight transportation from road to rail while improving logistics is that of Colombia. The country has several projects to rehabilitate rail corridors and implement logistics optimization strategies to boost transportation efficiency. The section dealing with waterborne and air transportation is also insufficient, partly because these sectors' emissions are not always accounted for in national calculations. Nevertheless, many LAC countries have significant levels of local activity in these modes, entailing the need to act upon these emissions. In this sense, Colombia mentions Performance-Based Navigation as a measure to reduce air transportation emissions. Meanwhile, Venezuela foresees the creation of an Energy Efficiency Management Plan, which would include incentives programs to renovate the air transportation fleet. At a global level, the conclusions are similar. Only 16 of the total 140 second-generation NDCs include guidelines to reduce emissions from local air and sea transportation (SLOCAT, 2022). In these spheres, NDCs tend to delay commitments until negotiations take place between international air (International Civil

Only four of the 24 second-generation NDCs in LAC indicate adaptation targets for transportation.

Aviation Organization, or ICAO) and maritime (International Maritime Organization, or IMO) organizations.

Mentions of "Adaptation" are scarce among the region's NDCs. In fact, this instrument was originally conceived for mitigation. Only four of the 24 second-generation NDCs set adaptation goals for transportation, focused on improving infrastructure risk management (Colombia, El Salvador), enhancing its resilience (including inland waterway navigation in Paraguay), and the adoption of climate resilience codes and standards (Dominican Republic). The same phenomenon is observed globally, with only 5% of second-generation NDCs containing goals targeting the sector. Despite being more numerous, adaptation measures are also limited, with 42% of the region's second-generation NDCs including actions in this respect, reflecting the global trend (40%). These actions are mainly in the NDCs of Caribbean and Central American countries, which are more prone to natural disasters. Countries focus on deploying infrastructure capable of resisting the impacts of CC, like Panama, that emphasizes the need to adapt its logistics infrastructure (ports, roads, bridges, and airports). The NDCs of Honduras and Haiti focus on protecting road networks, which are especially vulnerable to floods and cyclones in the region. Barbados plans risk management actions for its coastline, including the use of nature-based solutions (NBS). Paraguay acknowledges the vulnerability associated with navigating along its border rivers, and prioritizes planning and management actions in times of low water levels and droughts to reduce negative impacts on the economy due to potential disruptions of the Parana-Paraguay Waterway. Strengthening NDC adaptation policies will bring about benefits in terms of: (i) recognizing the risks of potential damages to the transportation sector and their effects on the economy and society; (ii) identifying actions to mitigate these risks; and (iii) prioritizing required funding measures within the efforts to combat CC. Some countries in the region are complementing their adaptation measures through NAPs and ADCOMs, as will be further discussed (section 3.2). It is worth noting that, among the 11 LAC countries with an ADCOM, seven have included it in their second generation NDCs (see Table 3.2). Therefore, the parts of these NDCs linked to adaptation consist of the ADCOM, where risks and vulnerabilities are laid out, adaptation priorities within the framework of the NDC, and support needed to implement these actions. Consequently, in these countries, assessment of the adaptation portion of their NDCs reflects their ADCOM commitments[7].

NDC goals are not always integrated with national policies and plans. Few national transportation strategies mention NDC goals. As we will further explore, Chile and Colombia are the exceptions. This overall absence suggests, on the one hand, that the translation of long-term goals into concrete actions is not planned or budgeted in local policies, and, on the other, that there is a certain lack of coordination between the agencies involved in developing the NDC and those with sectoral power. For implementation to go beyond the declared goals, NDC commitments must be reflected in national public policies and in a system that transforms these international commitments into national legislation. This coordination would allow: (i) prioritizing actions within the numerous areas comprising the transportation sector; (ii) coordinating with other government areas in charge of energy, environment, fiscal policies, among others; and (iii) obtaining resources to materialize the actions laid out in the NDC.

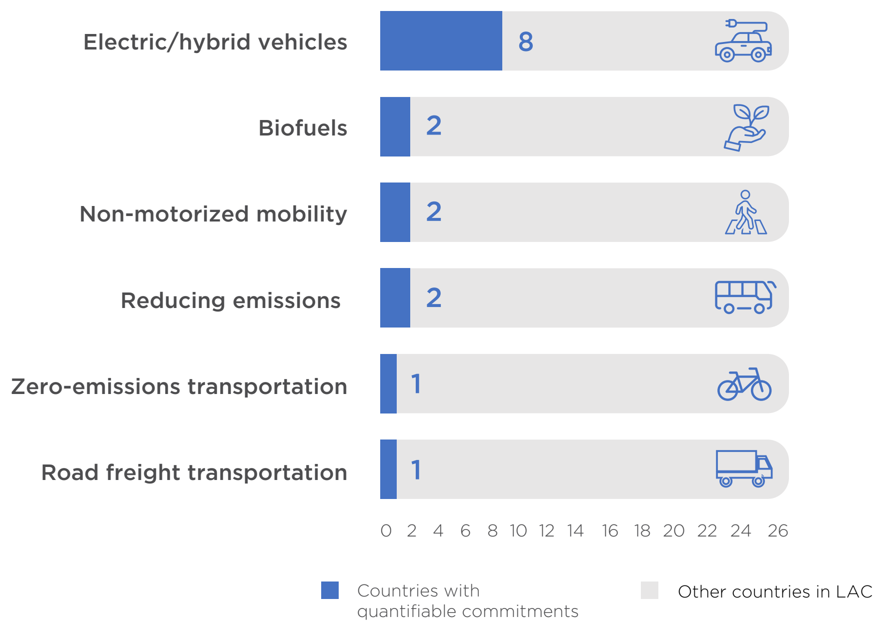
Information and monitoring systems are insufficient for goal achievement. Few NDCs include quantifiable goals (Figure 3.3) along with follow-up and evaluation frameworks for adaptation and mitigation measures, which help complement government efforts to mobilize public and private resources. Certain examples exist in Costa Rica, which is in the process of creating an institution to monitor goal performance through its National Climate Change Metrics System (*Sistema Nacional de Métrica de Cambio Climático, SINAMECC*), and in Peru, with the National Registry of Mitigation Actions (*Registro Nacional de Medidas de Mitigación, RENAMI*) in charge of compiling and managing data on GHG emissions reductions through mitigation measures. Meanwhile, Colombia expects the development of an Integrated Information System regarding Vulnerability, Risk, and Adaptation (*SIIVRA*, for its abbreviation in Spanish) to evaluate adaptation measures through the analysis of vulnerability change indicators. Mexico's ADCOM envisages the consolidation of an Information System on Transparency Progress (*SIAT-NDC*, for its abbreviation in Spanish) to integrate and follow up on mitigation, adaptation, and financing actions, while monitoring

7 Brazil, Colombia, Costa Rica, Ecuador, Panama, Paraguay, and Uruguay include the ADCOM in their NDCs. Chile, Haiti, Honduras, and Mexico have ADCOMs as independent documents.

the degree of progress of policies in these spheres, although this is not mentioned in the NDC. In fact, no second-generation NDC in LAC explicitly mentions a specific monitoring system for the transportation sector's mitigation and/or adaptation actions. At the international level, there are also not many references to monitoring and evaluation frameworks in NDCs. At the center of this absence is a lack of reliable data on the magnitude of transportation sector's emissions, methods for their calculation, and frequent monitoring mechanisms capable of identifying the impacts of implemented actions.

FIGURE 3.3.

Number of countries in LAC with quantifiable commitments in their NDCs



Source: Prepared by the authors based on UNFCCC (2023).

Note: The countries with quantifiable commitments for transportation in their NDCs are the following: (i) Electric and hybrid vehicles: Bahamas, Barbados, Belize, Bolivia, Colombia, Costa Rica, Paraguay, and Uruguay; (ii) Biofuels: Paraguay and Uruguay; (iii) Zero-emissions transportation: Costa Rica; (vi) Road freight transportation: Colombia; (v) Non-motorized mobility: Costa Rica and Dominican Republic; (vi) Reducing emissions: Belize and Trinidad and Tobago.

3.2.
Availability of other mechanisms to prioritize the transportation sector in the fight against CC

Seven LAC countries have LT-LEDS, out of 58 worldwide. The Paris Agreement invites, but does not oblige, member countries to formulate LT-LEDS. These identify the required transformations within development processes to ensure that they are consistent with a low-emission path. These strategies provide clarity about long-term goals and, to this extent, contribute to aligning actions to achieve the medium-term goals established in the NDCs (Climate Change Expert Group, 2020). In the region, the countries that have established LT-LEDS are Argentina, Chile, Colombia, Costa Rica, Guatemala, Mexico, and Uruguay. Among them, the transportation sector is mentioned in the LT-LEDS of Chile, Colombia, Costa Rica, Guatemala, and Mexico. With the exception of the latter, all other LT-LEDS include specific commitments for the sector. Chile, for example, has established that by 2050, GHG emissions must be 40% of the levels reported in 2018, while also identifying goals at the institutional level, the regulatory level, and for each mode of transportation, including areas such as innovation, inter-institutional collaboration, and private sector participation. Similarly, Colombia has set goals for each mode of transportation, also considering those referred to infrastructure.

Unlike NDCs, most of the actions for transportation belong to the "Shift" pillar. In this sphere, improving public transportation is highly prioritized. For example, upgrading public transportation is the first of the ten decarbonization axes identified in Costa Rica's LT-LEDS. To this end, the goal is to create an integrated and intermodal system by reorganizing routes, upgrading the concession scheme, simplifying the integration of bicycles, implementing electronic payments, and strengthening articulation between transportation and land use planning. Among its mitigation measures, Guatemala is prioritizing the expansion of public transportation infrastructure through investments in light rail, and improving service levels for public transit in the capital city. At the same time, active mobility has a relevant place in Chile's LT-LEDS, which identifies planning instruments required by 2030 to increase pedestrian and bicycle transportation, as well as coordination mechanisms to foster a more sustainable mobility. Other commitments

LT-LEDS reaffirm the importance of the energy transition on the path to decarbonize the sector.

refer to demand management, such as the increase of vehicle restrictions in urban areas and paid parking included in Costa Rica's LT-LEDS. Thus, actions to "Shift" complement those aiming to "improve", which are more present among NDCs, allowing these countries to rely on a larger number of actions available for the public sector to achieve a more sustainable mobility. In this sense, LAC countries' LT-LEDS differ from those established elsewhere, where 56% of the commitments belong to the "Improve" pillar, while only 13% belong to the "Shift" pillar (SLOCAT, 2022).

Among commitments in the "Improve" pillar, electromobility is in the spotlight. The second of the ten axes of Costa Rica's LT-LEDS aims at 95% of the light-duty vehicle fleet being zero-emission and running on renewable energies by 2050. They have therefore established: (i) short-term actions, dealing with pilots for public fleets, modifying government acquisition schemes, banning light-duty internal-combustion vehicle imports, consolidating a network of fast charging stations, and promoting the biofuel industry, among others; (ii) medium-term actions, such as the massive deployment of a smart charging network and funding to substitute the commercial fleet; and (iii) long-term actions, ensuring wide supply of vehicles, information, and financial instruments to consolidate electromobility. In addition, the strategy prioritizes decarbonization of public transportation through electrification and development of green hydrogen for buses, as well as the construction of an electric passenger train for the urban area of San Jose. Guatemala is prioritizing the development of electric vehicles and increasing the use of ethanol as biofuel. Colombia envisions that between 40% and 50% of large-city dwellers will use sustainable modes of transportation by 2050, backed by policies to adopt various types of electric vehicles. In this sense, LT-LEDS reinforce the importance of energy transition to decarbonize the transportation sector.

Compared to urban mobility, actions for other modes of transportation are scarce. Chile aims at gradually reducing the rate of emissions from maritime transportation, starting by 5% in 2023, to 11% in 2026, as compared to 2008. In the case of air transportation, the goal by 2030 is to enter the emissions offset program that makes part of the CORSIA agreement (Carbon Offsetting and Reduction Scheme for International Aviation) fostered by the ICAO, through the purchase and cancellation of emission units by local operators. The strategy also states that, by 2040, 100% of the electricity consumption of the state- owned rail company will be carbon neutral and, by 2050, 71% of the freight transportation fleet should be replaced by zero-emission vehicles. Meanwhile, Colombia aims at reducing the energy intensity of freight transport between 30% and 45% by 2050 compared to 2015, and restricting the operation of aircrafts surpassing a specific CO2 emission limit defined in line with technological surveillance. Costa Rica mentions the implementation of pilots to increase road freight transportation efficiency, the design of a plan to enhance the sector's overall efficiency, and collaboration with Central America regarding the development of standards aligned with the decarbonization process.

As in the region's NDCs, references to "adaptation" efforts are scant. However, Colombia's LT-LEDS does include climate-resilient measures for different modes of transportation. For example, it states that between 2030 and 2050: (i) transportation infrastructure must incorporate risk management and CC guidelines and implement NBS in critical areas to reduce damages and losses due to CC and extreme meteorological events; (ii) 100% of the country's aviation and airport infrastructure must reduce climate risk; (iii) 100% of new national road designs throughout the country must incorporate green road infrastructure guidelines; and (iv) there must be a robust information system for risk management and CC adaptation for every mode of transportation. The importance of technology for risk management is underlined establishing that, starting on 2030, 100% of projects in the primary and secondary road networks should be carried out incorporating Smart Roads[8] criteria.

LT-LEDS identify potential flaws or risks associated with the measures when they are not sufficiently backed up or planned ahead. Costa Rica identifies the potential risks of long-term carbon dependency (lock-in) for mobility and recommends "avoiding investments in infrastructure that favor the use of private vehicles instead of public transportation [...] and avoiding the promotion and adoption of transitional transportation

8 Smart Roads infrastructure relies on the Internet of Things and ICTs to generate, collect, and analyze data to inform traffic management. It also provides information for long-term decarbonization strategies.

The objective of having a NAP is to strengthen medium- and long-term adaptation planning.

technologies that create barriers for the decarbonization of transport." To avoid this, it suggests using methodologies of Decision-Making Under Deep Uncertainty, through which different scenarios are created and actions to be implemented for each of them are identified. These considerations are useful to inform subsequent NDCs and to assess whether the short- and medium-term actions are in line with what has been outlined in the LT-LEDS. Tackling these kinds of risks requires close coordination between LT-LEDS application based on long-term scenarios and the short-term planning processes and investment strategies (IRENA, 2023). In this sense, there are several challenges for LAC countries: developing LT-LEDS for those who do not have them, further specifying the required measures for the transportation sector, incorporating measures covering the full "Avoid-Shift-Improve" spectrum, considering the different modes of transportation, and initiating the systematic implementation of actions on adaptation, which also includes a comprehensive vision of infrastructure systems.

Nine countries in LAC have National Adaptation Plans (NAPs), out of 45 available globally. They are: Brazil, Chile, Colombia, Costa Rica, Guatemala, Paraguay, Peru, Suriname, and Uruguay – all of which have adaptation measures related to the transport sector. In cases like Brazil, Chile, and Peru, they even have specific NAPs for the infrastructure sector. The goal of having a NAP is to strengthen medium- and long-term adaptation planning, identifying priority areas and action lines to reduce CC vulnerability. Among the elements that most NAPs have in common, the ones that stand out the most are those related with generating information and developing early warning systems, strengthening inter-institutional collaboration as well as collaboration with local authorities, conducting awareness campaigns, and promoting innovation. In this, they resemble European and Asian NAPs. However, upon comparison, the region's NAPs fail to clearly identify agencies or institutions in charge of implementing each action, collaborators, performance indicators, and sources of funding. This constitutes a major constraint to the implementation of NAP commitments, leaving it more as a statement of intent.

Urban mobility is mentioned in most of the region's NAPs. Brazil's NAP identifies reduced traffic safety (e.g. traffic crashes), mass transport systems performance drops, increased travel time and costs, and potential logistics disruptions as the main impacts of CC. Among the axes prioritized by the NAP, it underlines the need to strengthen mass transportation systems, incorporate climate resilience criteria in its infrastructure, and make operations flexible through inter-modal connectivity. Uruguay's NAP highlights the need to further advance coordination between land use and transportation planning to reduce long- distance journeys, which is also related with the mitigation agenda. It is worth noting that this NAP incorporates the gender perspective as part of the transformation into an environmentally and socially sustainable mobility. This NAP clearly identifies which government agencies are responsible for promoting each line of action. Chile's sectoral NAP for cities also mentions the need to boost integrated and inter- modal planning by including regulatory measures related with universal accessibility, walkability, and inclusive cycling[9] (Government of Chile, 2018). To this end, it stresses the need to take steps towards implementing measures to reduce urban heat islands.

Ensuring infrastructure resilience, especially for road infrastructure, ranks high among NAP priorities. Among its strategic goals, Suriname includes roads resilience to heavy rains or floods, and roads hydrological sensitivity to help preserve hydrological processes and ecosystems. Guatemala is committed to goals such as increasing strategic road infrastructure that considers climate risks by 5% and reducing road infrastructure affected by extreme events by 5%. To this end, the country intends to generate and apply risk assessment methodologies, update construction and maintenance standards, develop mechanisms to verify those standards, and design contingency plans by type of extreme event. In its Transportation and Communications NAP, Peru details actions required to strengthen institutions and train their personnel to design and modify the rules applicable to this sector based on disaster risk management methods. Paraguay also stands out, prioritizing inland waterway transportation –their entry point to international markets–

9 Cycling-Inclusive Policy seeks to integrate the use of bicycles in the transportation network under safe and efficient conditions (IDB, 2015).

There is a gap in the region's NAPs in terms of clearly identifying which entities are responsible for implementation, which are the compliance indicators, and which are the sources of financing.

regarding the need to properly manage navigation conditions in cross-border rivers during times of water scarcity and droughts. To this end, it promotes the creation of climate scenarios and hydrological models that allow identifying required infrastructure investments for the Parana-Paraguay Waterway, as well as the dialogue to reinforce planning and monitoring of construction works and dredging in the context of the Intergovernmental Committee for the Parana-Paraguay Waterway. At the same time, Chile's Infrastructure Services NAP defines specific annual goals to incorporate CC in infrastructure project planning and evaluation processes.

ADCOMs are either presented as separate documents or alongside an NDC or NAP. In LAC, seven countries have an ADCOM directly integrated in their NDCs or NAPs, while four others possess ADCOMs as separate documents: Chile, Haiti, Jamaica, and Mexico. These last two have included actions linked to the transportation sector. Mexico underlines the importance of technology to increase resilience in mass public transportation infrastructure, while Jamaica focuses on evaluating the vulnerabilities and climate risks of ports and airports through Jamaica's Systemic Risk Assessment Tool (J-SRAT). Other adaptation measures for transportation included in the ADCOMs of the remaining countries are part of the aforementioned and analyzed NDCs.

The region's only NAPA was issued by Haiti in 2006 and does not make extensive reference to transportation. It only mentions it as one of the sectors vulnerable to coastal climate risks (floods/cyclones) that paralyze maritime transportation. Overall, few NAPAs include transportation-specific measures, mostly limiting themselves to citing the effects of natural disasters on roads and other infrastructure. Instead, these documents focus on actions for sectors such as water, sanitation, and agriculture. Since NAPs were introduced, countries have prioritized this new adaptation framework that contains a long-term vision and is more deeply integrated with national development than NAPAs, which are a collection of short-term activities that respond to urgent and immediate CC adaptation needs, particularly to guide finance from international development funding. In effect, given the magnitude of the climate challenge, it is instrumental to shift from ad hoc adaptation approaches based on projects to a more sustainable and systemic process that integrates adaptation into national, sectoral, and local plans (NAP Global Network, 2016).

It is essential to move from ad hoc, project-based approaches for adaptation to a more sustained and systemic process of mainstreaming adaptation into national, sectoral, and local plans.

In the region there are several NAMAs related to transport. Of the four UNFCCC policy frameworks analyzed in this document, NAMAs are the most concrete framework thanks to the possibility they offer of presenting "individual actions" or government projects that must be executed in line with specified pre- established goals, deadlines, and budgets and under the responsibility of a specific authority. For example, Ecuador has published two "individual" NAMAs for the implementation of CC mitigation strategies, which include actions oriented at freight and passenger transport through the provision of funding for fleet renovation and the development of information and result verification tools. Colombia has a NAMA dedicated to freight transport that includes designing programs to enhance the fleet's efficiency and renovation. Chile has a NAMA for downtown Santiago that includes measures to promote zero- or low- emission municipal fleets of taxis and buses, installation of charging stations, as well as infrastructure deployment and redesign of traffic management for active mobility.

TABLE 3.2. **Summary of LAC countries that mention transportation in the mechanisms established by UNFCCC**

Country	Does the country have an NDC that mentions the transportation sector?	Does the country have LT- LEDS that mention the transportation sector?	Does the country have a NAP that mentions the transportation sector?	Does the country have an ADCOM that mentions the transportation sector?	Does the country have a NAPA that mentions the transportation sector?	Does the country have NAMAS registered in the transportation sector?
Argentina	Yes	Yes	No	No	No	Yes
Bahamas	Yes	No	No	No	No	No
Barbados	Yes	No	No	No	No	No
Belize	Yes	No	No	No	No	No
Bolivia	No	No	No	No	No	No
Brazil	No	No	Yes	Yes	No	No
Chile	Yes	Yes	Yes	Yes	No	Yes
Colombia	Yes	Yes	Yes	Yes	No	Yes
Costa Rica	Yes	Yes	Yes	Yes	No	Yes
Ecuador	Yes	No	No	Yes	No	No

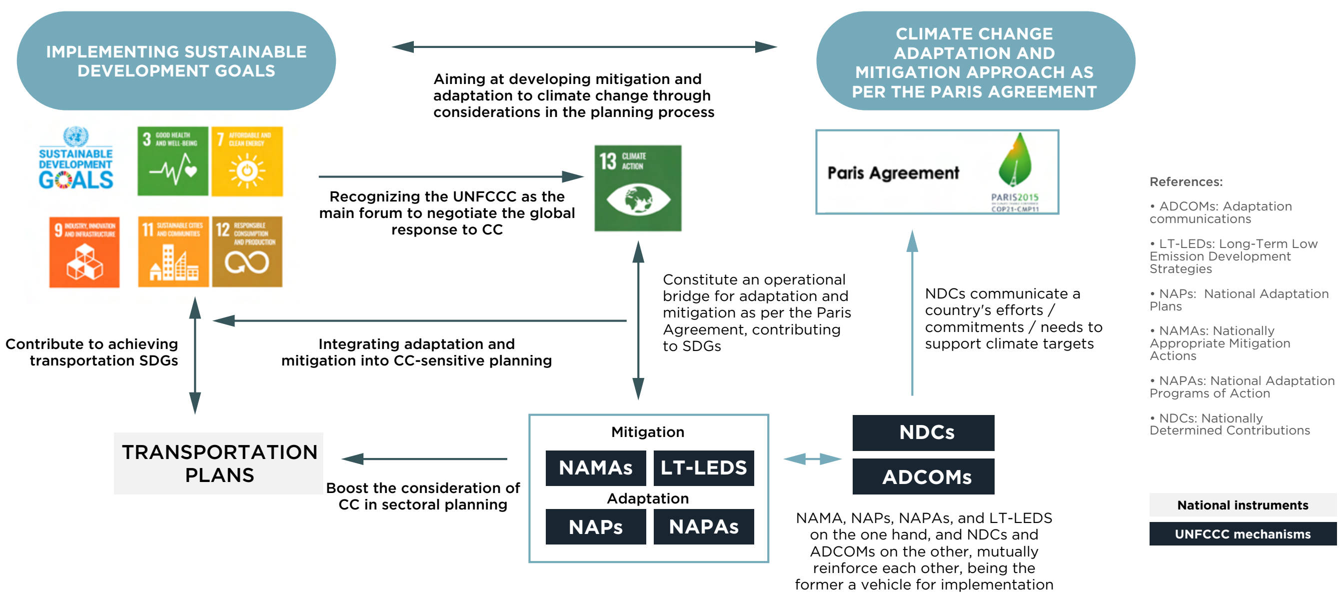
Country	Does the country have an NDC that mentions the transportation sector?	Does the country have LT- LEDS that mention the transportation sector?	Does the country have a NAP that mentions the transportation sector?	Does the country have an ADCOM that mentions the transportation sector?	Does the country have a NAPA that mentions the transportation sector?	Does the country have NAMAS registered in the transportation sector?
El Salvador	Yes	No	No	No	No	No
Guatemala	Yes	Yes	Yes	No	No	No
Guyana	No	No	No	No	No	No
Haiti	Yes	No	No	Yes	Yes	No
Honduras	Yes	No	No	No	No	No
Jamaica	Yes	No	No	Yes	No	No
Mexico	Yes	Yes	No	Yes	No	Yes
Nicaragua	No	No	No	No	No	No
Panama	Yes	No	No	Yes	No	No
Paraguay	Yes	No	Yes	Yes	No	No

Country	Does the country have an NDC that mentions the transportation sector?	Does the country have LT- LEDS that mention the transportation sector?	Does the country have a NAP that mentions the transportation sector?	Does the country have an ADCOM that mentions the transportation sector?	Does the country have a NAPA that mentions the transportation sector?	Does the country have NAMAS registered in the transportation sector?
Peru	No	No	Yes	No	No	Yes
Dominican Republic	Yes	No	No	No	No	No
Surinam	No	No	Yes	No	No	No
Trinidad and Tobago	Yes	No	No	No	No	No
Uruguay	Yes	Yes	Yes	Yes	No	No
Venezuela	Yes	No	No	No	No	No

Source: Prepared by the authors based on UNFCCC (2023).

The broad and non-binding nature of the mechanisms established by the UNFCCC makes it necessary to set up policies that materialize goals at the national and local levels. With the exception of NAMAs, due to their nature, the mechanisms established by the UNFCCC do not include details about specific projects or actions. On the contrary, they usually limit themselves to provide guidance on relevant issues to combat CC and offer general approaches for intervention. Therefore, in order to guarantee the materialization of these broad strategic guidelines, it is crucial to link them to sectoral and cross-cutting national policies and to use them to identify actions and instruments for their pursuance. As will be discussed in Chapter 4 and is summarized in Figure 3.3, benchmark countries rely on a wide array of public policy tools that range from planning to investing in technology and innovation. Chile and Colombia constitute good LAC examples in this sense (Figure 3.4).

FIGURE 3.4. **Interactions between mechanisms provided by the UNFCCC**



Source: Prepared by the authors based on NDC Partnership (2023).

BOX 3.1.

Integration of CC and transportation policies: Chile and Colombia as examples for LAC

In 2022, Chile approved its Climate Change Framework Act, establishing regulations to approach CC challenges and acknowledging the commitments included in its NDC. The law stipulates the creation of sectoral mitigation and adaptation plans, including the transportation sector, along with a set of concrete measures to achieve these goals. In addition, Chile's 2021 National Strategy for Sustainable Mobility lays out seven goals and 30 measures to achieve a sustainable urban mobility model that allows reaching carbon neutrality by 2050, as envisioned in the country's NDC. The guidelines state that mobility should be integrated with the territory and be clean, efficient, active and safe, inclusive, participatory, informed, and transparent. To foster the application of these measures, a National Sustainable Mobility Program is under development as a tactical and financial instrument at the national, regional, and local scales. Specific public policy instruments are aligned with NDC goals, such as Chile's 2022 Action Plan to Reduce Greenhouse Gas Emissions from International Civil Aviation, or the 2021 National Electromobility Strategy.

The latter defines strategic and regulatory axes and contains a precise action plan to encourage technology and research in this field, in order to foster the arrival of more energy-efficient vehicles, improve the country's competitiveness in this field, and comply with CC policy commitments and energy-saving goals.

Colombia has developed a battery of planning tools and national public policies to guide regional and local governments in the transition towards sustainable mobility. The Climate Action Law of 2021 integrates the goals set in the NDC into national legislation, including those referred to the transportation sector. Next, Colombia's National Sustainable Transport Strategy of 2022 defines four strategic axes to achieve these goals: (i) regulatory and policy- oriented; (ii) technical and technological; (iii) economic and market-related; and (iv) charging infrastructure. It also lays out an action plan stating who is accountable for each activity as well as a timeline for its implementation. In addition, the country has set out specific plans to develop the required technologies to achieve NDC goals, such as the National Strategy for Electric Mobility, which identifies the main regulatory instruments, prices, non-financial instruments, and public investments to foster technological development.

3.3.
Conclusions on the adoption of UNFCCC mechanisms in LAC

• 19 countries in the region have included transportation-related measures in their NDCs, while only two countries (Trinidad and Tobago and Belize) have set goals to reduce transportation emissions by 2030.

• Most mitigation measures included in LAC NDCs are related with the "Improve" pillar, mainly focusing on promoting the electrification of public transportation and the taxi fleet. Measures in the "Shift" pillar also refer to public transportation, focusing on enhancing its quality. Actions in the "Avoid" pillar are scant among NDCs, leading to current NDCs not taking full advantage of the framework of actions that, in its entirety, would be conducive to deeper reductions of the sector's GHG emissions.

• Overall, NDCs focus on passenger transportation, paying little attention to freight transportation, one of the main sources of emissions in the region. Furthermore, only four of the 24 NDCs include specific adaptation goals for the transportation sector.

• Few national transportation strategies refer to NDC goals, suggesting on the one hand, that the translation from long-term goals into actions is not planned or budgeted in local policies, and, on the other, lack of coordination between the agencies involved in developing the NDC and those with sectoral mandates.

• Seven countries in LAC have LT-LEDS in place, out of a world total of 58. Most transportation efforts belong to the "Shift" pillar, promoting the enhancement of public transportation and active mobility. As in NDCs, little attention is paid to freight transportation and CC adaptation.

• Nine LAC countries have NAPs in place, out of 45 available worldwide. These countries stand out for formulating a call to generate data and install early warning systems, strengthen collaboration between institutions and with local authorities, conduct awareness campaigns, and promote innovation. However, these NAPs do not identify which agencies are responsible for implementing each effort and which agencies are collaborators, what are the performance indicators, and which will be the sources of funding.

• Only Haiti has a NAPA, and it makes no reference to transportation. However, there are many NAMAs in the region related to the sector, mainly laying out actions for urban mobility.

• The general, non-binding nature of mechanisms established by the UNFCCC creates the need to set up sectorial and cross-cutting policies that materialize goals at the national and local levels and enable identifying required actions and instruments to reach those goals.

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Moving the green frontier in transportation

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4. Moving the green frontier in transportation

Coordination of actions at the global level is urgent to address CC.

Public policy actions, properly designed and implemented, are crucial to tackle CC. The environment is a clear example of a public good[10], where public policy intervention is required for its safeguarding. CO2 emissions that contribute to CC constitute a threat to this good, so it is key to both mitigate this externality at the local level, and coordinate actions globally to ensure the survival of life on the planet. Transportation is one of the main sources of CO2 emissions, which, together with other market failures such as congestion, information asymmetries, and coordination failures between different actors in the sector, generates the need to develop public policy actions that direct the transportation sector towards the objectives established by the Paris Agreement.

Over the past ten years, international benchmark countries have developed a set of policies promoting mitigation of transportation emissions and adaptation of the sector to CC. Although there are different strategies, and different modes of transportation are emphasized according to their importance at the national level, the general trend in benchmark countries can be summarized in five main areas of action: (i) prioritization of decarbonization and adaptation in sectoral plans; (ii) availability of a set of instruments to promote actions on decarbonization and adaptation; (iii) institutional modernization to assume the task of planning, coordinating and supervising such actions; (iv) close collaboration and coordination with other government agencies; and (v) generation of alliances with the private sector, academia and civil society.

10 This type of goods is characterized by being non-rival and non-exclusive. Non-rival means that their enjoyment by one person does not diminish the ability of others to enjoy the same good, while non-exclusive means that people cannot be prevented from enjoying the good. (Kotchen, 2012).

Countries that are leading the transformation of the sector towards sustainable transportation models are becoming role models.

Based on these five areas, the objective of this chapter is to carry out an international review of experiences that can serve as a guide to move the green frontier of transportation in LAC, both in terms of mitigation and adaptation to CC, based on best practices and lessons learned from benchmark countries at the global level. These countries are characterized by being at the forefront in one or more of the five areas of action indicated above, with initiatives that are generating a positive impact for the transformation of the sector, providing guidance and interesting examples of measures that can be adapted to the region. The reviewed experiences correspond to both national and subnational levels. In some cases, these experiences include LAC countries themselves, which are already at the frontier in some aspects of public policy. Given that transportation involves different subsectors, where specific actions and coordination of different actors are required, the chapter begins with a sector-wide policy review, followed by those corresponding to urban mobility, road, maritime and air transportation[11]. These experiences will be used as a reference for the analysis of the situation in LAC countries and the elaboration of the roadmap for the region contained in Chapter 5.

4.1. Regulatory and institutional framework for the transportation sector

All benchmark countries have a set of plans that put the fight against CC as one of the sector's main challenges. One of the most important functions of governments is sectoral planning, which establishes objectives, investment priorities, and work agendas for the public agencies that manage the sector. It also creates a conceptual framework within which plans for specific subsectors are developed and articulated. Benchmark countries modify their transportation plans or formulate new ones to apply, at the national level, the international commitments

11 The most relevant subsectors for the region are considered in terms of the volume of passengers and transported freight. Road transportation focuses mainly on freight transportation and aspects associated with interurban transportation, while urban mobility includes both public and private passenger transportation, as well as freight transportation.

assumed for transportation decarbonization within the framework of the Paris Agreement, their NDCs, and other mechanisms provided for by the UNFCCC. Thus, national transportation plans in benchmark countries are based on the recognition that the fight against CC is an essential component and lever for the development of the sector (Box 4.1).

There are additional economic, social, and strategic goals to promote alignment with the Paris Agreement. Benchmark countries' transportation plans mention objectives such as: (i) positioning themselves as first movers in the transition of one or more subsectors (for example, production of electric batteries or supply of net-zero emission fuels); (ii) mitigating energy transition's economic impact on key sectors for the economy, such as the automotive, maritime or aviation industries; (iii) attracting investments and generating green jobs that compensate for those that may be lost in the transition; (iv) leading the setting of standards at global level; and (v) improving people's quality of life by reducing local emissions and environmental pollution. Thus, there also are economic and social policy objectives that are aligned with reducing GHG emissions, within the framework of a reconfiguration of the development model. Thus, sectoral plans usually mention actions in different areas, such as industrial, energy, education, and labor policies.

BOX 4.1.

CC prioritization within transportation plans

In the face of the threat of CC, transportation plans and strategies are considering measures to reduce emissions from the sector and increase the climate resilience of transportation systems and infrastructure. The proposed measures are not just limited to changing the sector's energy sources, but also aim to avoid and shift travel to more sustainable modes, favor intermodality to take advantage of the most environmentally efficient modes, promote CC adaptation, and establish coordination mechanisms to align actions with other sectors such as

Transportation plans and strategies are key instruments to guide the decarbonization and resilience of the sector.

energy, environment, commerce, and industry. In addition, transportation plans include a mitigation and adaptation action plan that allows clearly establishing the sector's investment priorities.

The US Department of Transportation's Strategic Plan 2022-2026 considers that transportation has a key role to play and must be part of the solution to the climate crisis (U.S. Department of Transportation, 2022). To this end, it defines three lines of action: (i) reduce air pollution and GHG emissions from transportation and move towards a sustainable transportation system to achieve a net zero emissions economy by 2050; (ii) improve the resilience of transportation infrastructure; and (iii) promote climate and environmental justice with a focus on reducing the negative environmental impacts of transportation on disadvantaged communities. It also includes performance indicators, such as reducing aviation GHG emissions to 2019 levels or below by 2030, and developing transportation resilience improvement plans for 50% of the country's states by 2026. Similarly, the Australian Infrastructure Plan emphasizes the need to integrate resilience concepts into planning (Infrastructure Australia, 2021). Thus, it incorporates the methodology of decision making under uncertainty to reduce the vulnerability of infrastructure to CC. It also highlights the role of electric mobility in achieving transportation emission reduction targets, and identifies actions in this area. Scotland's National Transport Strategy, subtitled Protecting Our Climate and Improving Lives, identifies climate action as one of its four priorities (Transport Scotland, 2020). To this end, it focuses on the goal of sharply reducing transportation sector emissions in order to achieve the national goal of net zero emissions by 2045. It also refers to the sector's adaptation measures to natural disasters such as erosion, landslides and sea-level rise, mainly for vulnerable communities, and highlights the economic costs of poor adaptation. Finally, it emphasizes the need to incentivize behavioral change to reduce transportation demand and facilitate mode shift. The promotion of mode shift is also highlighted in Switzerland's transportation plan Mobility and Territory 2050, which notes that, due to the ever-increasing volume of traffic, the reduction of environmental pollution through technological advances is only partial (Confédération Suisse, 2021). The plan sets out several action strategies, including closer coordination between land use plans and transportation to promote sustainable development, and the need to ensure the integrated operation of the transportation system.

At European level, the Fit for 55 plan includes the most ambitious proposals that currently exist at the global level to review and update the European Union legislation, in order to reduce its GHG emissions by at least 55% by 2030. Within this framework, several regulations are being considered for adoption, three of which are directly related to transportation. The first, ReFuelEU Aviation, obliges fuel suppliers to gradually increase the proportion of sustainable fuels they distribute, such as synthetic electro-fuels, and rules out the use of feedstock crops in biofuel production. Airlines and airports are also subject to certain obligations. The second, FuelEU Maritime, aims to increase the use of sustainable fuels by vessels over 5,000 tonnes that stopover at European ports. Lastly, the regulations on CO2 emission limits for cars, vans, and heavy-duty vehicles are being revised. These measures are accompanied by financial incentives such as the social climate fund and energy taxation, and by pricing mechanisms such as the emissions trading system.

Good inter-sectoral coordination and coordination between levels of government are key to the success of decarbonization policies and strategies in the sector.

Adaptation is becoming increasingly important in sectoral planning. All benchmark countries mention CC adaptation as one of the sector's most important aspects. Beyond NAPs (see Chapter 3), many countries have developed specific adaptation strategies by subsector, as well as for specific geographic areas. Transportation adaptation strategies are also found at the subnational level, as in the case of the Transport Climate Change Adaptation Action Plan of the State of Victoria in Australia, or the Climate Action Plan for Transportation Infrastructure of the State of California, and even at the Transportation Authority level, as in the case of Transport for London (TfL). In general, these strategies focus on boosting infrastructure resilience, building capacities to improve response to shocks, training the workforce, and increasing available financing for the sector.

Given CC's crosscutting nature, the objectives set out in transportation plans should be coordinated with national plans for environment and energy. In benchmark countries, the Ministries of Environment or similar establish plans to fight against CC, which recognize the importance of transportation in this task. Based on this, transportation plans identify the actions and their required timing to achieve sectoral objectives, within the broader CC plan at the national level. For example, Spain's Long-Term Decarbonization Strategy 2050 considers that transportation is one of the greatest challenges to decarbonize the country. In this sense it states that, as a result of measures envisaged in the Integrated National Energy and Climate Plan, renewable energy should have a share of 28% in transportation by 2030 and emissions should be reduced by more than 30% during the same decade (MITECO & Government of Spain, 2020). Next, the Safe, Sustainable and Connected Mobility Strategy 2030 refers to the 2050 Decarbonization Strategy and identifies 18 measures to achieve its goals, grouped into four areas: (i) promotion of alternative and sustainable energy sources; (ii) promotion of low-emission modes of transportation; (iii) sustainability of transportation facilities; and (iv) reduction of other types of environmental pollution (MITMA & Government of Spain, 2021).

It is key to coordinate sectoral decarbonization with energy transition plans, given that reducing transportation emissions requires new propulsion sources. For example, France's Energy and Climate Strategy analyzes the country's energy trends for each transportation mode, establishing energy mix scenarios for the decarbonization of each mode

(Ministère de la Transition écologique et solidaire & Gouvernement français, 2020). The document includes the Clean Mobility Development Strategy, evidencing the close relationship between transportation and energy transition. An example in LAC is Chile's National Energy Efficiency Plan 2022-2026, which contains measures for the transportation sector geared towards electric vehicles and the charging network, research and innovation in efficient and zero- emission transportation, and training in the field of energy efficiency for the sector (Ministry of Energy & Government of Chile, 2021).

Sector plans are complemented by strategies for specific subsectors. Considering the complexity of the decarbonization process of each transportation, subsector, together with national plans, benchmark countries have addressed urban mobility, road transportation, maritime transportation and air transportation through specific plans (see Sections 4.2 to 4.5). Looking at plans that focus on a specific subsector, it is worth noting the number of instruments related to urban mobility that stress the role of decarbonization in driving improvements in the quality of public transportation, air quality, and social inclusion. In the maritime subsector, the plans recognize the importance of decarbonization as a factor of competitiveness and attraction of new investments. A good practice to highlight in specific plans at the subsector level is the inclusion of roadmaps to advance their implementation, identifying the actions to be carried out by the public, private, or joint sectors.

Additionally, there are plans focusing on promoting a particular technology. The promotion of electric mobility is of particular interest, with plans that not only include the components related to mobility, but also other topics such as industrial development, integration of artificial intelligence (AI) solutions, and the deployment of charging infrastructure. In many cases, this is related to the importance of the automotive industry in the productive matrix of the countries and the need to increase its efficiency and sustainability to meet the goals stipulated in the NDCs. Examples of this are actions to promote the electric vehicle industry within the US Bipartisan Infrastructure Act, which include an Electric Vehicle Charging Action Plan, and USD 17 billion to support the national supply chain of batteries of the Advanced Technology Vehicles Manufacturing Loan Program (Calatayud et al., 2022). On the energy transformation side, hydrogen industry development plans can generate significant benefits for transportation decarbonization. The UK strategy refers to the key role of hydrogen in complementing emission reductions from the electrification of buses, trains, and heavy-duty vehicles, and highlights that it can provide a solution to sectors that cannot otherwise be fully decarbonized, such as aviation and maritime transportation (UK Government, 2021). In this context, the government launched several investment programs to finance the development of the hydrogen industry within each transportation subsector. For its part, Chile's National Green Hydrogen Strategy aims to develop green hydrogen and its derivatives (methanol, ammonia and synthetic fuels) to decarbonize, among other sectors, land, sea, and air transportation, while turning into one of the world's leading producers of this renewable fuel by 2040 (Ministry of Energy & Government of Chile, 2020).

Benchmark countries' sectoral and subsectoral plans refer to a variety of instruments to incentivize decarbonization and transportation resilience. In general, these can be classified into five groups: (i) regulations limiting pollutants emissions; (ii) procurement processes that include environmental criteria; (iii) pricing instruments; (iv) non-financial incentives; and (v) public sector investments. The regulations establish goals, standards, obligations and other actions defining the "rules of the game" for the sector in order to establish a behavior framework for its actors and reduce the uncertainty generated by the transition. The procurement processes refer to the goods and services acquired or contracted by the State in the different modes of transportation, which are governed by a regulatory framework that determines their characteristics, as well as the obligations and rights of the parties. Pricing instruments involve the granting of tax exemptions, subsidies, or other monetary resources in order to encourage certain actions in the sector, as well as the imposition of taxes and penalties to discourage others. Non-financial incentives use non-monetary mechanisms such as the exchange of knowledge, alliances with the private sector and academia, research promotion, and awareness programs, among many others, to generate changes in the behavior of transportation actors that are consistent with the objectives of the fight against CC. Finally, States and subnational governments make investments directly in the sector, in the form of infrastructure provision and service delivery, through which they can promote decarbonization. Recognizing the specificities of each transportation mode, these instruments are often developed and implemented at the subsector level, with the required content and combination to achieve the specific goals. For this reason, they are discussed in detail in Sections 4.2 to 4.5.

Specific and specialized teams are required to design and implement policies, programs, and instruments. All benchmark countries have units in charge of CC mitigation and adaptation within their sectoral agencies, starting with the Ministries of Transportation or similar. As in the private sector, these units are headed by a Chief Sustainability Officer (CSO), who leads an interdisciplinary team. The team is made up of specialists in transportation, the environment, and information technology, among others, who use different scientific and applied approaches to analyze the sector's challenges, establish policies, and monitor them. All benchmark countries evidence good practices related with strengthening institutional capacities to tackle the CC challenge, including the provision of resources, continuous training in an area that is in full development, the exchange of experiences at national and international levels, and close coordination with other sectoral and government areas. One example is that of the UK's Department for Transport, which has a Transport Decarbonization Directorate that includes offices of Decarbonization Strategy, Low Carbon Fuels, Zero Emission Vehicles, and Environment and Future Mobility Analysis. It is interesting to note that this Directorate is part of the same group as the Directorates of Science, Innovation and Technology, Analysis, and Future Transport Systems, showing the close relationship between transportation decarbonization, technological innovation and the field of research. Likewise, within the German Ministry of Transport, each department responsible for a subsector (maritime and air transportation, federal road transportation) has an office focused on CC and environmental issues. They also coordinate with the Department of Transport Policy, which includes a directorate on CC, Mobility Mitigation, and Environmental Protection.

Without data, it is not possible to assess the challenge or measure progress in the fight against CC. That is why benchmark countries have emission inventories for the sector, subsectors, and geographical areas of interest in the first place. There is a typology of inventories available globally. The GHG Protocol is an international reference proposing standardized tools for measuring and managing GHG emissions, widely

Emission inventories are key to dimensioning the challenge and measuring progress in the fight against CC.

used by companies and organizations. C40 has also developed a tool, the City Inventory Reporting and Information System (CIRIS), which is a methodology for municipal governments to measure sectoral emissions, including transportation. At the national level, mention can be made of the Spanish Emissions Inventory System (MITECO & Government of Spain, 2023), which has a national GHG Inventory as well as a national inventory of air pollutants that provide data for the country's air, maritime, and road subsectors. These inventories are updated with certain periodicity, varying between annual and five-year frequency. On the other hand, since 2001, the Austrian national inventory has been reviewed annually by sectoral teams before being formally submitted to the UNFCCC and the EU. The data set is broken down by subsectors of the economy, including different modes of transportation, and includes information on fuel consumption and emission factors by activity, among other elements (Umweltbundesamt & Environment Agency Austria, 2022). The continuity of the process over time –the inventory has existed for more than twenty years– allows for a historical perspective and an evaluation of the effectiveness of implemented policies.

Digitization and the use of state-of-the-art technologies in data analysis are key for data collection, emission estimation, and the production of decision-making scenarios (Box 4.2). For example, the Climate TRACE tool, from the non-profit organization of the same name, allows emissions inventories to be carried out through satellite images and AI. The latter detects indicators of GHG emissions in satellite images, such as hot spots, which are linked to real databases. The combination makes it possible to estimate GHG emissions by transportation subsector. Thus, inventories can be generated where traditionally there have been no data or mechanisms to obtain them. For example, the tool is tested in collaboration with regional governments to develop subnational emission inventories (OECD Forum Network & Sridhar, 2023). On the commercial side, there are several examples of platforms that allow monitoring GHG data in real time and in precise geographical areas thanks to satellites, terrestrial sensors, traffic, and other devices combined. These can be used to monitor a transportation network and assess its real contribution to the decarbonization of the territory, or to monitor prior to the implementation of a decarbonization plan. A key aspect is collaboration with the private and academic sectors. Here we can mention the role of Citepa (Interprofessional Technical Center for Studies on Air Pollution) in the preparation of the national GHG inventory of France. This non-profit association acts as an operator for the French Environment Ministry, auditing emission inventories, compiling and analyzing statistics and sectoral experts' work, and disseminating information to professionals and public and private operators. Citepa brings together 85 members (industrialists, professional federations and unions, energy producers and distributors, consultancies, research organizations, air quality monitoring associations, etc.), which provide enough diversity and information sources to ensure its transparency and independence. In LAC, the Metropolitan Area of the Aburrá Valley (Colombia) stands out for collaborating with different actors when carrying out its GHG inventories. In 2021, it partnered with the World Wide Fund for Nature (WWF) and the Institute of Hydrology, Meteorology, and Environmental Studies (IDEAM) to carry out its inventory, which is composed of several subsectors including road, rail, and air transportation (Ministry of Environment et al., 2021).

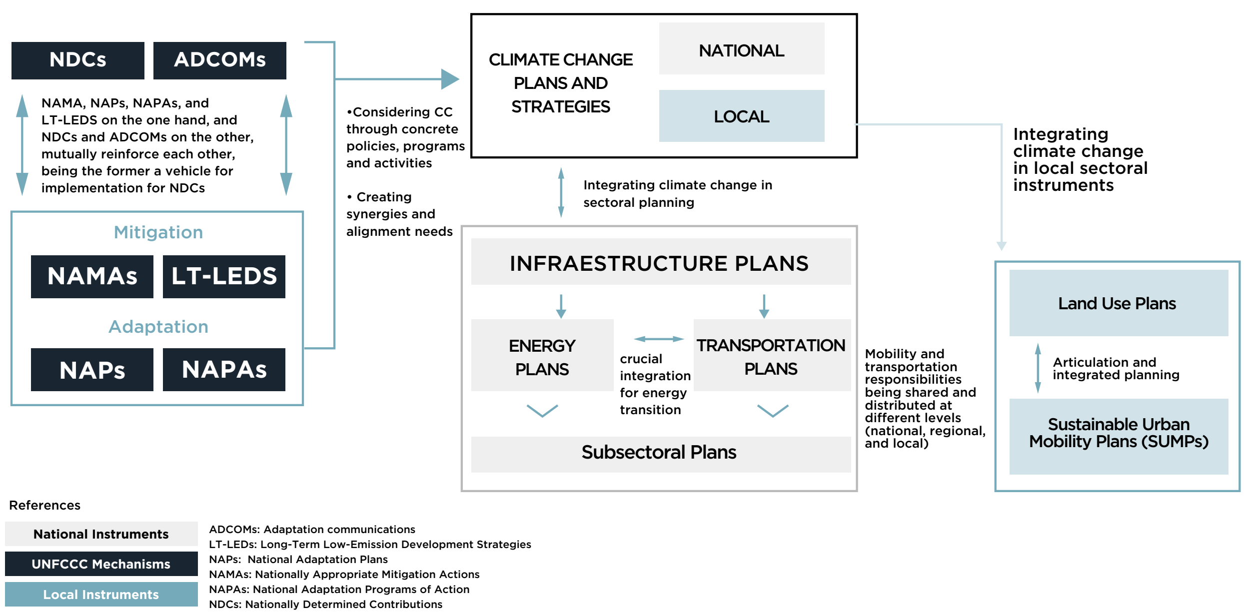
BOX 4.2.

The importance of digital transformation for CC mitigation and adaptation

Emerging technologies can bring multiple solutions to the transportation sector in its efforts to address CC. On one hand, they can improve the availability, precision, and granularity of information related with key topics such as generated emissions or the behavior of climate variables, allowing better risk assessment, impact modeling, and decision making. On the other hand, they can boost the efficiency of processes and thus generate energy consumption savings and reduce emissions of polluting gases. In this area there are significant advances in AI for the design of routes that minimize emissions levels; life cycle assessment platforms for road projects that help estimate and identify areas of emission reductions; platforms that facilitate shared mobility, mobility as a service and integration of transportation systems; digital twins to simulate transportation and energy interactions; and systems based on video detection and AI for road asset management, among others.

Close collaboration and coordination with other government agencies is key to align and achieve decarbonization goals. To the extent that described plans and instruments to deal with CC are developed and implemented by different institutions –including within the transportation sector–, there is a need to ensure coherence between public policies, so that the development agenda for a specific technology or energy source is aligned with the objectives of the general plans for the sector and the country's policy to fight against CC (Figure 4.1). Responding to this need for public policy coherence, most benchmark countries have created inter-institutional coordination mechanisms, usually in the form of inter-ministerial committees, which are used to define priorities, establish joint actions, and align sectoral interventions. Some committees are specific to transportation, within which decarbonization is addressed along with other sectoral issues. One example worth mentioning is the United Kingdom and its Inter-Ministerial Group for Transport, which involves four administrations, including the Welsh Ministry of Climate Change. Other committees directly address CC, including the transportation sector. For example, Singapore established in 2007 an Inter-Ministerial Committee on Climate Change with the presence of the Ministry of Transport. The Committee includes several workgroups, including one on policies and infrastructure needed for long-term emission reductions, and another on resilience and sustainability. Effective coordination requires unified political commitment and leadership from the executive branch, emphasizing the importance of the fight against CC as a government priority, as a mechanism to improve the quality of life, and as a way to generate new opportunities in the context of a change in the development model. For these committees to be successful, they must be convened and chaired by the highest appropriate authority, whether at the national or sectoral level; have a clear purpose; be composed of decision-making authorities to facilitate action; have a roadmap with defined milestones and deadlines; and include the perspective of the private sector, academia and civil society (Calatayud et al., 2022).

FIGURE 4.1. **Articulation of NDCs with national, local, and sectoral CC instruments**



Source: Prepared by the authors.

A fundamental aspect is the coordination within the public sector and with the private sector, academia, and civil society.

This coordination must also take place at the vertical level, with regional and local governments. The fundamental role of these levels is evident in the case of urban mobility, which is generally planned, regulated and supervised by regional and local authorities. The same applies to road transportation, where subnational authorities have powers and control transit over secondary and tertiary roads, or to Port Authorities, which have control over a specific port. In this regard, the analyzed experiences show three courses of action: (i) provide guidelines from the central government for the formulation of specific policies at the regional and local levels; (ii) strengthen the capacities of local authorities to carry out planning, regulation and supervision; and (iii) generate coordination committees between national, regional and local authorities, to align objectives and monitor progress. For example, the administration of Italy's main ports is entrusted to port authorities under the control of the Ministry of Transport. Their main function is to plan, coordinate, promote and guide ports development, while port operations are transferred to private concessionaires. Governance and coordination at different levels in ports is carried out by port committees comprising national, regional, provincial and municipal elected officials, as well as representatives from port companies. In the case of urban mobility, the German Federal Ministry for Transport and Digital Infrastructure leads a Transport Committee that deals with various policy issues (road construction, automotive technology, research, environmental protection in the sector, legislative affairs, general transportation policy, etc.), involving representatives of the federal states and major cities, and holding monthly meetings.

Benchmark countries generate strategic alliances with the private sector, academia, and civil society to advance the decarbonization of transportation (Box 4.3). First, these actors participate in the design of national and subnational plans through prior consultations and working groups with the public sector. A good practice used in the United Kingdom is the preparation of prospective studies in conjunction with academia, which are used as supporting documents for the development of public policies for the promotion of transportation decarbonization. A second, widely used mechanism is the elaboration of agreements for the development of pilots with specific technologies and for a greater supply of renewable energy for the transportation sector. In this sense, there are numerous examples of pilots in different latitudes for the deployment of electric and hydrogen buses, where equipment suppliers, transportation operators, and local/national administrations collaborate to test the technology and the operating and business models. Finally, as with the digital transformation, benchmark countries have hammered out agreements with companies and universities to create research and training centers for specific technologies –such as electric mobility–, for a subsector or, in general, for the promotion of sustainable transportation. For example, IMO and the EU have created Technology Cooperation Centers for the Maritime Sector at universities on five continents, which seek to build capacity and information to mitigate CC. At a national scale, the University Transportation Centers program created by the US Department of Transportation funds consortia of universities to develop research and capacity-building skills in leading technologies. Through pilots and research and training centers, the public sector can generate spaces for experimentation that provide information for the development and adaptation of regulations, for example, around standards and safety. In addition, it aligns Research and Development (R+D) actions of companies and universities with environmental sustainability objectives for the sector pursued by public policy.

BOX 4.3.

The role of the private sector in the decarbonization and resilience of transportation

Six actors that are encouraging transportation decarbonization can be identified within the private sector: (i) large transportation operation companies, in all modes, that have objectives to reduce their emissions of scopes 1, 2 and 3 as part of their corporate social responsibility plans and to comply with requirements from national and international funders; (ii) the automotive, airline, and shipping industries, which are developing units with lower energy consumption and units that use renewable energy; (iii) energy companies, which are investing in the development, supply and, in certain modes, operation of transportation fleets using renewable

The private sector is progressing at different speeds in the decarbonization of transportation.

energy; (iv) the financial sector, which has begun to include sustainability requirements for granting financing, in addition to providing resources that facilitate the investments necessary to develop and scale up actions to reduce emissions and adapt to CC; (v) the insurance sector, which is requiring greater transparency and information on the CC risks to which the object to be insured is exposed; and (vi) technology companies, which develop and commercialize both decarbonization and adaptation solutions.

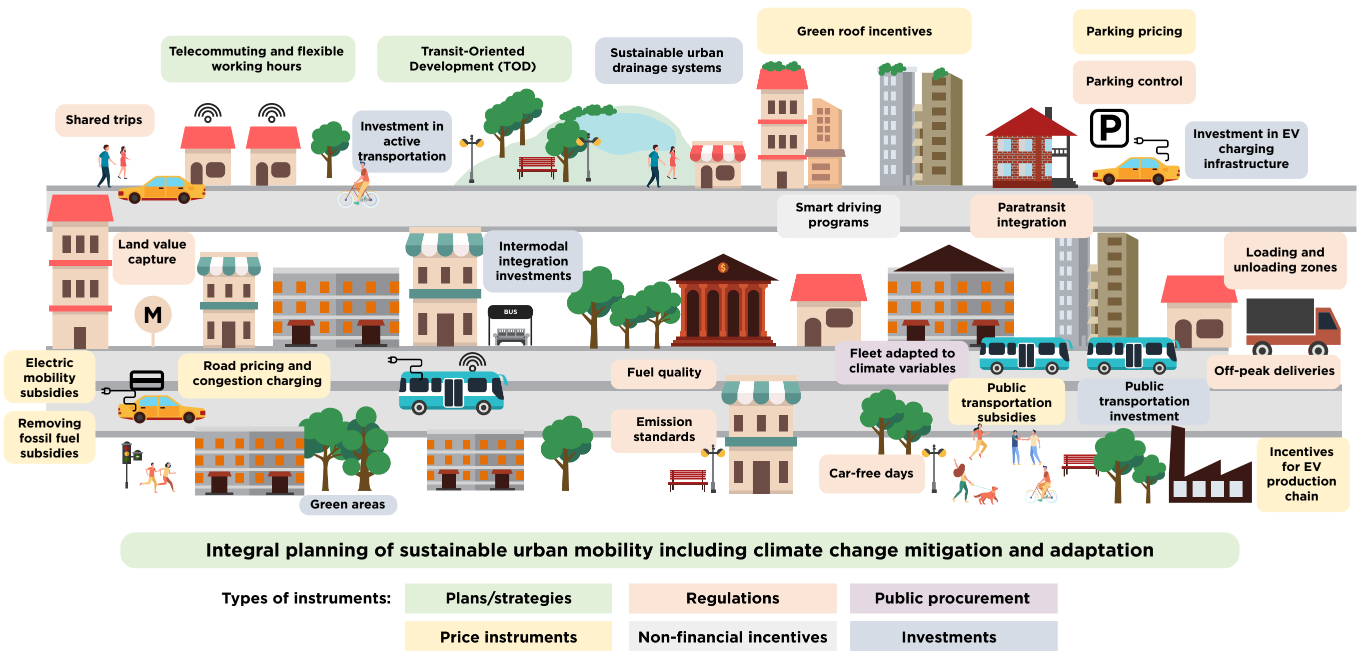
To a large extent, transportation decarbonization shares characteristics with the processes of technological transformation. Competitive pressures, international regulations, corporate image, and financiers' requirements motivate large global companies to invest in the development and adoption of technologies, and the reconfiguration of processes to improve their sustainability (see Calatayud et al., 2022). This influence spills over to companies involved in their supply chains, including transportation operators, to reduce Scope 3 emissions from large companies. In many cases, they work together to implement solutions that reduce polluting emissions at the level of the entire chain, as well as solutions that reduce the risk of disruption in the face of climate events, also improving adaptation to CC.

However, as in the processes of technological transformation, there are different speeds, where some players are at a disadvantage, including: (i) relatively smaller companies; (ii) companies that do not participate in global supply chains where technology and standards spread more rapidly; and (iii) companies in geographies and sectors where decarbonization has even less international momentum (e.g. long-distance freight transportation in sectoral matters). To reduce this gap, benchmark countries have developed programs that encourage energy conversion through subsidies and public credits; channel resources at lower rates via private banking; and generate skills and knowledge in smaller companies, among others.

4.2. Measures for urban mobility decarbonization and adaptation

Advancing in the decarbonization and adaptation of urban mobility to CC requires a comprehensive approach, including measures in different policy areas for this subsector and in coordination with other government sectors. This subsection identifies successful measures implemented by benchmark countries in different action areas. However, these measures should not be considered in isolation. Successfully achieving decarbonization and adaptation objectives requires a combination of policy measures and a joint approach to them (Figure 4.2).

FIGURE 4.2. **Urban mobility decarbonization and adaptation***



Source: Prepared by the authors
Note: *Non-exhaustive list of measures

4.2.1 MITIGATION MEASURES

Urban mobility –passengers and freight– is one of the main contributors to transportation sector emissions and city air quality deterioration, participating with 27% of the emissions of the sector at the regional level (ITF, 2023a). At the same time, this subsector is where greater progress has been verified in terms of decarbonization as a result of the adoption of sustainable mobility plans and the combination of regulations, incentives, and public investments framed in the "Avoid-Shift-Improve" scheme, widely recognized by the international community (see Chapter 3).

Urban mobility decarbonization creates an opportunity to achieve resilient, sustainable, affordable, and equitable transportation systems (Box 4.4). It is not just a matter of creating alternatives to traditional combustion systems. Instead, it consists of developing mobility forms that increase accessibility, revitalize local economies, improve the quality of air and urban life, reduce congestion, provide alternatives to the private vehicle at lower costs and with greater road safety guarantees, and generate health benefits. This will ensure a just and inclusive transition that considers all social groups, geographical areas, genders, ages, and people with special mobility needs. The resulting improvements in access to opportunities and better urban living standards are key potential aspects that must be actively communicated to citizens to accelerate the uptake of new forms of sustainable mobility.

BOX 4.4.

Integral planning of sustainable urban mobility

Although there are multiple definitions of sustainability in the literature, this concept is generally related to the importance of meeting the needs of current generations without compromising the ability to meet the needs of future generations. In the context of urban mobility, sustainability encompasses considerations of three main types: environmental, social, and economic. Environmental considerations usually receive greater attention within sustainability, with strategies focused on GHG reduction to mitigate the environmental impacts of transportation. Social considerations are related to the provision of sustainable, equitable, safe, and high-quality transportation services that adequately meet the needs of populations with all types of skills over time. A social vision of sustainability also seeks to ensure that the burden of CC mitigation actions and the consequences of CC on transportation systems do not fall disproportionately on the most vulnerable groups. Finally, economic considerations seek to ensure that investments, subsidies and financing sources used in the construction, operation and maintenance of current urban transportation systems do not jeopardize the availability of future resources to meet the projected needs of urban mobility, while ensuring affordability for users.

Urban transportation systems have great potential to increase equity through inclusive access of the population to educational and work opportunities, goods, and services. To develop this potential and at the same time contribute to the reduction of GHGs and the improvement of air quality, sustainable mobility strategies should not seek to reduce emissions in isolation, but also improve transportation conditions for the most vulnerable populations, including efficiency, safety, universal accessibility, and affordability. Lower-income populations have higher participation in public transportation and active mobility, spend a larger share of their income on transportation, travel larger distances, and are more exposed to pollution and hazards from CC (Giuliano & Hanson, 2017; Scholl et al., 2022). Faced with deficiencies in public transportation and infrastructure for cyclists and pedestrians, lower-income populations

Emission reductions must be part of a broader strategy to promote sustainability.

are increasingly turning to more polluting and less safe alternatives, such as motorcycles. On the other hand, public transportation systems have historically been designed based on peak demand during peak hours for commuters. Optimizing transportation systems considering only this type of travel means that other travel patterns have poor service levels, such as trips related to the care of children and the elderly, tasks that occur during the off-peak period and are usually performed by women (Scholl et al., 2022). Lack of a gender perspective in urban mobility planning represents one of the main obstacles for women to gain access to employment opportunities, as evidenced by an International Labor Organization (ILO) survey showing a 15.5 percentage point reduction in the likelihood of women's participation in the labor market, as a result of limited transportation options in development countries (SLOCAT, 2021a).

Road safety is a key factor that is often overlooked in sustainability analyses. Road deaths are the tenth leading cause of death worldwide, and are expected to move up to fifth place by 2030 according to WHO estimates. Despite representing the least risk to other users, pedestrians and cyclists are the most likely to suffer injuries or death in the event of an crash. More than 270,000 pedestrians and around 41,000 cyclists die each year around the world (WHO, 2018). In LAC, some 109,000 people lost their lives in 2018 due to road crashes (PAHO, 2019). An estimated 23.5% of traffic fatalities in the region involved pedestrians and 7.1% cyclists (IDB, 2023). This not only represents a huge problem in terms of public health and equity, but also creates an additional limitation for strategies seeking to reduce GHG emissions through mode shift towards public transportation and active modes.

To reverse the current situation, the design of infrastructure, speeds and vehicles must be conducted under the Safe System Approach. Public transportation stops and stations must allow the safe passage of users separated from vehicle traffic. Sidewalks must be passable and comfortable for all users, including children, the elderly, and people with reduced mobility. Investments must be made in segregated

Sustainable mobility includes road safety and universal accessibility.

bicycle infrastructure that provides adequate safety and accessibility conditions. Speed limits must be defined according to the types of road users, the dynamics of each area, and land uses, taking into account that safe speeds (under 50 km/h in urban contexts and 30 km/h in high density areas to reduce risks of collision and severity of injuries) not only reduce traffic crashes, but can also reduce emissions. As progress is made in the development of cleaner vehicles, active and passive safety standards for motor vehicles should also be incorporated and enforced. At least 20 of the 50 best-selling vehicle models in large LAC markets are rated between 0 and 3 stars within the Latin NCAP safety classification (IDB, 2023). Additionally, it is estimated that in a period of 15 years, more than 4,000 deaths from road crashes could be avoided in the region if vehicle safety standards were applied in Argentina, Brazil, Chile and Mexico (IDB, 2023).

Ensuring the social sustainability of urban mobility implies recognizing that existing transportation systems have been designed prioritizing the needs of a small part of users, so it is necessary to implement strategies that correct these biases to ensure sustainable mobility in terms of equity. Urban transportation planning should seek to prioritize pedestrians, cyclists, and public transportation users, improve the quality and affordability of public transportation, ensure road safety, have a gender approach, implement universal accessibility criteria in infrastructure design, and include CC resilience considerations. Failure to consider the needs of all potential users within urban mobility planning will limit transportation systems' potential to reduce equity gaps and at the same time hinder efforts to attract a significant share of users to transportation modes that generate fewer emissions. At the international level, successful experiences in different areas stand out, such as Madrid's integration of public transportation (infrastructure and operations, fares, and information) (Vassallo & Bueno, 2019), Singapore's integrated land use and transportation planning (UITP, 2021a), and Vancouver's decline in private transportation use together with public transportation and active transportation improvements (Litman, 2023).

In terms of economic sustainability, it is key to recognize that some of the strategies focused on making urban transportation less polluting and more equitable also improve its economic efficiency. Investments in public transportation and infrastructure for cyclists and pedestrians are much more cost-efficient than investments required for the construction, operation and maintenance of road infrastructure for private vehicles (SLOCAT, 2021a). Investments required for the adaptation of urban transportation systems will be lower in cities that prioritize the most sustainable and efficient modes of transportation, compared to the costs associated with increasing maintenance frequency and reinforcing or relocating large areas of road infrastructure for the use of private vehicles. In particular, the return on investment in active transportation infrastructure may be significantly higher than other transportation works (Scholl et al., 1996). Public policies aimed at integrated transportation and land use planning can achieve reductions in the number and extent of urban trips and their associated emissions, as well as the operating costs of transportation systems.

The current focus on transportation sector decarbonization represents an opportunity to promote strategies focused on the social and economic sustainability of urban transportation systems. Strategies focused exclusively on technological advancement and emission reductions limit the potential of urban transportation to improve quality of life and ensure equitable access to employment opportunities and goods and services, while being more expensive. In addition, the benefits of emission reductions can be cancelled out if there is increased migration to private modes (Scholl et al., 1996). The synergies and dependencies between the different components of sustainability make the development of strategies to achieve equitable and economically sustainable transportation systems a necessary requirement to achieve their environmental sustainability.

In different latitudes, countries and cities have made the promotion of sustainable mobility a pillar of their transportation and urban development plans. To this end, measures are identified in terms of land use planning, comprehensive urban mobility planning, public transportation improvement, promotion of active mobility, and collaboration with the private sector, within a holistic vision of sustainable urban development. Examples of this are found for different city sizes, such as Tampere (Finland), Madrid (Spain), Mitovica (Kosovo), Rio de Janeiro (Brazil), and Belgrade (Serbia). In the specific case of Madrid, the creation of the Madrid Regional Transport Consortium in 1986, responsible for infrastructure planning and operations –together with other measures such as large-scale investments in the system–, have been fundamental for the system to be recognized as one of the best practices for the integration of public transportation, registering a growth of 46% in the number of users in the period 1986-2015 (Vassallo & Bueno, 2019). At a global level, best practices indicate that achieving the objectives of transportation and urban development plans requires a multidisciplinary and inclusive approach supported by citizens and the private sector, which allows different social sectors to make more sustainable mobility decisions, and proposes mechanisms to evaluate the impact of mobility campaigns on local populations. This approach is included in the Sustainable Urban Mobility Plans (SUMP), whose adoption is recommended by the European Commission for the 424 largest cities in the Union, in order to meet the mobility needs of people and companies, from a perspective of sustainability, safety, inclusion, and quality of life (European Commission, 2021).

Local and metropolitan transportation authorities play a key role in generating and implementing such plans. They are responsible for planning mobility in their areas of influence, either at the city or metropolitan level. In its Urban Mobility Framework, the European Commission encourages EU cities to adopt a mobility planning process based on eight principles: (i) plan for sustainable mobility of the entire "functional city"; (ii) define a long-term vision with a clear implementation plan; (iii) develop all modes of transportation in an integrated manner; (iv) measure performance levels; (v) improve quality; (vi) collaborate between institutions; (vii) involve citizens; and (viii) monitor and evaluate the plan's implementation. The promotion of public transportation, active mobility, and CC resilience are aspects of particular

Achieving the targets of the NDCs requires close coordination between different levels of government.

interest for SUMPs. Having these plans in place allows the aspirations of NDCs to be realized at the subnational level, as well as to feed the revisions of NDCs according to the local perspective. It also makes it possible to establish the relationship between the measures included in the plans and the SDGs, providing benefits beyond the energy transition. In this context, the European Commission makes available different resources to support transportation authorities in the generation and implementation of SUMPs. A large number of cities have created the figure of Head of Sustainability/Climate Change as well as specific units for the design and implementation of measures in this area.

Vertical coordination is important to ensure consistency between the objectives established at the country level and the goals and actions to be carried out at the local level. A large part of the NDCs include targets for the electrification of the public transportation fleet, the deployment of infrastructure for active mobility, and integrated land use and transportation planning, among others (see Chapter 3). Usually, it is the cities that have jurisdiction over these areas, so it is essential to ensure the alignment of urban mobility plans with the commitments assumed by the country. For example, in Costa Rica, the Comprehensive Plan for Sustainable Urban Mobility of the Metropolitan Area of San José, and in Colombia, the mobility master plans of the city of Manizales and the Aburrá Valley area (Medellín and surroundings), are consistent with those stipulated by the countries in their NDCs in terms of promoting public and active transportation through infrastructure, modal integration, and promotion of higher density urban development around stations and public transportation services (SLOCAT, 2022b).

Information and communication technologies (ICT) are useful tools to achieve high-impact solutions in urban mobility. Digital technologies reduce information asymmetries when planning a trip, which facilitates multimodality in the mobility of people, allows greater efficiency in the transportation of goods (optimizing loads and reducing empty trips), and can contribute to facilitate the introduction of electric mobility by reducing uncertainty about battery recharging options. In relation to public transportation and shared mobility, they make schedules easily available through apps or at transportation stations, facilitate the integration of schedules between different operators or modes, and allow electronic ticket purchases. In turn, these technologies can reduce transaction costs by facilitating payments via mobile applications or web platforms. In the field of traffic demand management[12], they facilitate the implementation of congestion charging, road pricing, and access control or mobility restrictions (Calatayud et al., 2022). Therefore, policymakers should take advantage of digital developments by including them in the design of sustainable mobility policies.

The following is a summary of best practices identified at international level for the promotion of decarbonization and sustainability of urban mobility, according to the "Avoid", "Shift", and "Improve" pillars, identifying the policy instruments –regulations, public procurement, pricing instruments, non financial incentives, and investments– that are used with this objective.

4.2.1.1. "AVOID" PILLAR

"Avoid" measures aim to reduce the need for motorized travel, without limiting access to goods and services. A key mechanism to achieve this goal is integrated and equitable land use and transportation planning, as it defines and regulates interactions between decisions related with land use and transportation infrastructure and services, determining the urban areas designated for public and private transportation infrastructure, the availability of transportation services, and the relative accessibility and costs of urban developments, with an approach that prioritizes the integration of vulnerable populations (Scholl et al., 2022). In this context, TOD has proven to be an effective approach to reduce private travel, which promotes the use of public transportation and non-motorized transportation modes through the implementation of high-density, mixed-use, and environmentally sustainable urban development with access to public transportation within walking distance (Box 4.5). Curitiba, Denver and Hong Kong are different examples of how these types of policies contribute to achieving dense, compact and multimodal cities, reducing congestion and increasing demand for public transportation (IDB, 2020). Actions within sustainable mobility plans aiming at a more efficient use of road space through the prioritization of public transportation are also of great importance (Arsenio et al., 2016). The experiences of cities such as San Francisco, Washington

12 It is important to bear in mind that the success of a measure depends on the complementarity and articulation with the rest of the measures implemented.

DC, Seoul, Tokyo, and Freiburg show the relationship between these instruments and mode shifts in favor of public and active transportation (Cervero, 1994, 2007; Goletz et al., 2016; ICLEI Local Governments for Sustainability, 2023; Tamakloe et al., 2021; ITF, 2021).

BOX 4.5.

Transit-Oriented Development

TOD is a tool that allows cities to mitigate (and adapt to) climate change. This urban planning model is based on dense and compact urban development that promotes the use of more socio-environmentally efficient transportation modes. It promotes walking based on a densely connected and safe network of sidewalks, the use of bicycles through dedicated infrastructure, access to a high-quality and high-capacity public transportation network, mixed land uses, regulation on the use of road infrastructure, and limits on the parking supply for private vehicles (ITDP, 2017). Thus, planning focuses on creating urban spaces for people rather than vehicles. The advantage of a TOD approach lies in its ability to contain urban sprawl, reduce air pollution, GHG emissions and the urban heat island effect, generate public spaces, promote mixed land use, and improve the overall quality of life. Due to its characteristics, this type of urban development contributes significantly to climate adaptation in terms of disaster risk management and prevention.

Despite the clear advantages of implementing urban projects under a TOD logic, the success of these initiatives depends on multiple and interdependent elements, ranging from the planning and design of infrastructure, streets, and buildings, to institutional, legal and financial reforms. Various participants with different visions and interests are involved in the implementation of these projects, such as decision makers from an array of organizations, technicians from various disciplines, urban developers and investors, current and future residents, and civic organizations. For this reason, a large-scale TOD project must start with consensus-building and an action framework based on collaboration. Successful examples of urban projects with these features are found in New York with the Broadway Boulevard Project, in Singapore with its pedestrian street system, in Vancouver with its Olympic Village, and in London with the Central Saint Giles project (C40, 2016b).

Teleworking measures and flexible working hours are strategies that can reduce travel demand and, consequently, mitigate GHG emissions and local pollutants in the subsector. Commuting is one of the main reasons for citizens to travel. However, restrictions imposed during the COVID-19 pandemic showed that certain types of jobs can be done remotely, using ICT. In Italy, the implementation of teleworking for the public sector of Bologna, Rome, Turin, and Trento resulted in a reduction of at least 3.8 kg of CO2 per day for each employee, only considering the emissions saved from travel in private modes (Roberto et al., 2023). As a complementary measure to teleworking, flexibility and staggering of working hours are good demand management practices to reduce congestion and the level of polluting emissions. For example, the public sector in Bogotá is allowed to arrive to work between 6 am and 9:30 am, as a way to reduce rush hour congestion. Given the positive relationship between congestion and pollution, reducing travel demand at peak times has a direct effect on decreasing local pollutants (Bedoya-Maya et al., 2022).

Regulations incentivizing car sharing[13] are considered a good practice to discourage vehicle ownership and achieve greater efficiency of private vehicle travel. Over a distance of 500 km within the EU, a solo journey in a gas or diesel car can generate more emissions per passenger than air travel (EEA, 2020). Recent analyses show that car-sharing services have reduced both the annual kilometers traveled in vehicles/person, and car ownership. In the Netherlands, car-sharing users reduced the annual distance of their journeys in private vehicles by 1,750 km, implying a reduction in emissions of up to 392 kg CO2eq per year (Nijland & van Meerkerk, 2017). In Scotland, new car-sharing users reduced car ownership by up to 47%, while in France and Germany they did so by up to 23% and 15%, respectively (Vélez & Plepys, 2021). The generalization of these services, through an extensive network, immediate availability

13 The shared mobility concept usually includes different mobility services. Car-sharing services allow the flexible rental of vehicles for short periods of time, for example hours or days, with different modalities (station-based, free floating, and person to person - P2P). Ridesharing (or carpooling) services include shared car trips by individuals contacting each other through a mobile application or website. The car's private owner makes unused seats available to other passengers. In ride-hailing (or ride-sourcing) services, users book a ride through an app and the vehicle is not shared with other users, while in the case of ride-pooling several passengers share the driver.

Travel avoidance measures also apply to freight transportation.

of vehicles, and charging and parking infrastructure, can contribute to reducing ownership and dependence on private vehicles. Also, vehicular infrastructure access regulation, such as exclusive high-occupancy lanes, is a way to promote car sharing among people with similar destinations, with benefits in terms of emission reductions. Analyses conducted for the San Francisco Bay Area, in the United States, showed that the implementation of high-occupancy lanes produced a 30% reduction in person-hours traveled (Cassidy et al., 2010). To maximize the environmental benefits of shared mobility in its different modalities (including current ones such as car-sharing, ride-sharing, and ride-hailing, and potential ones such as shared autonomous vehicles), adoption of zero- and low-emission vehicles should be promoted, as well as coordination and integration of these services with those of public transportation.

There are also measures within the "Avoid" pillar that are aimed at urban freight transportation. Regulations on the delivery of goods outside peak hours and the assignment of special loading and unloading zones have a positive effect on GHG emissions and environmental pollution reduction, to the extent that they achieve logistical optimization by reducing the kilometers traveled by the cargo fleet. Off-peak delivery of goods prevents cargo vehicles from travelling through urban infrastructure during peak congestion hours. In New York and Sao Paulo, these measures were shown to reduce environmental pollution by between 45% and 67%, respectively (Holguín-Veras et al., 2018). On the other hand, special loading and unloading areas are a low-cost solution to facilitate logistics operations, avoiding congestion and obstruction to pedestrian mobility. In Madrid, both the city's Madrid 360 Environmental Sustainability Strategy and the Madrid 360 Sustainable Mobility Plan contemplate automated control measures for the management of urban distribution of goods and, in particular, loading and unloading areas. The design of an intelligent application for loading and unloading increases the availability of free spaces and rotation, and helps logistics operators optimize routes, improving efficiency in logistics management and reducing polluting emissions produced by this economic activity (Madrid City Council, 2023). In addition, using alternative modes to traditional cargo vehicles such as electric cargo bicycles and light cargo vehicles, contributes to improve system efficiency and reduce emissions. The use of digital twins can be another tool to reduce trips in the urban distribution of goods, as evidenced by the results of the LEAD project carried out in Madrid. This project, funded by the European Commission, has made it possible to optimize logistics distribution in the city center through the use of a freight consolidation hub in facilities managed by the Municipal Transport Company (EMT Madrid), obtaining reductions of up to 33% in the number of kilometers travelled and the consequent saving in emissions. As pricing instruments, congestion and parking charges seek to correct the negative externalities of urban freight transportation. In Washington DC, the use of dynamic prices in commercial loading zones reduced the time spent searching for parking by seven minutes, resulting in less congestion and emissions (IDB, 2020).

4.2.1.2. "SHIFT" PILLAR

These measures promote travel migration from energy-intensive and polluting transportation modes to more energy-efficient and environmentally sustainable modes. In this sense, it is most desirable to switch from trips in private and motorized modes to trips in zero-emission public transportation and active modes. For this, it is crucial to have sustainable mobility and infrastructure plans prioritizing the metro, the tram, buses, cyclists, and pedestrians, as well as promoting accessibility and integration of public transportation systems with other modes. The measures also seek to retain public transportation users by improving level of service and making streets more suitable for walking and cycling. They should be accompanied by regulations, pricing instruments, non-financial incentives, and investments rationalizing the use of private transportation, such as congestion and air quality charges, parking control, low-emission zones and limited traffic zones. Measures on this front contribute to the improvement of access to opportunities and thus to equity, as long as the least polluting and most efficient transportation modes in the use of space and access to opportunities are available to the entire population, without discrimination.

Investment in public transportation infrastructure and integration with other transportation modes are crucial to ensure quality services. Both are key factors in achieving a mode shift, improving transportation system access, coverage, reliability and frequency, and reducing travel times (Yañez-Pagans et al., 2019). For example, in Lima, Peru, investment

Promoting high-quality public transportation is key to achieving modal shift.

in a bus rapid transit (BRT) system with exclusive lane reduced travel time by 34% and increased satisfaction of public transportation users, achieving a BRT acceptance level of 82% two years after its completion (Scholl et al., 2015). In Guangzhou, China, the dedicated-lane BRT system was integrated with metro systems and with pedestrian and bicycle infrastructure. This made it possible to increase the speed of buses and mixed traffic by 29% and 20% respectively, saving 52 million hours of travel in 2010, with an estimated annual value of USD 24 million (C40, 2016a). England's national bus strategy for post-pandemic recovery called Bus Back Better also emphasizes the integration of transportation systems, relying on the use of technology to improve system frequency and reliability (Department for Transport, 2021a).

Increasing the use of public transportation also requires improving its affordability. In this sense, demand subsidies make it possible to direct efforts specifically to the sectors in most need. Some LAC countries and cities establish preferential quotas and/or free public transportation service for people of lower socioeconomic status, people with disabilities, women, or children (Scholl, Fook, & Barahona, 2022). An example of this is the BRT system in Bogota, where lower-income users receive a discount on the general fare (Pike, 2010; Transmilenio S.A., 2023). It is estimated that this subsidy increased monthly trips of beneficiaries by 56% (Rodríguez Hernández & Peralta-Quiros, 2016). Other systems have decided to implement zero-fare to ensure service affordability for the entire population. However, the cost-benefit and effectiveness of these programs to encourage change from more polluting modes to public transportation remains to be assessed, given that mode shift depends more directly on level of service improvements (UITP, 2021b). In Tallinn, Estonia, one year after the zero-fare policy was introduced, demand for public transportation increased 14%, improving the mobility of lower-income residents (Cats et al., 2017). In Germany, the State of Hesse introduced zero fare for 145,000 public employees, with positive impacts on the use of public transportation for work and leisure travel (Busch-Geertsema et al., 2021). In Madrid, since the end of the COVID19 pandemic and in collaboration with the Municipal Transport Company of Madrid (EMT Madrid), the City Council periodically establishes the free use of municipal buses on high-traffic days (such as the start of school activity after the end of school holidays, etc.) or during episodes of high pollution. Up to the date of this report, the Madrid City Council has activated this measure in 36 days, transporting more than 30 million people, of which more than nine million were non-habitual users of public transportation.

Affordability and sustainability of public transportation systems require strong funding strategies by governments. Given the nature and positive externalities of public transportation, its optimal provision requires stable government support to ensure affordable prices for users and the financial sustainability of systems. In all OECD member countries there are funding and financing mechanisms for public transportation systems from different sources. In Paris, for several years now, payroll taxes from large employers have helped finance public transportation services (Urssaf, 2023). In London, an additional charge to commercial property tax has been used to develop specific infrastructure, such as Tube lines. Another way London raises resources for public transportation infrastructure is through planning rules, which limit the density and developments of offices and multi-story housing according to the capacity of public transportation systems in the immediate vicinity of these projects. Thus, if builders want to develop projects with higher densities than those allowed in zones with public transportation accessibility, they must make investments to expand public transportation infrastructure (Blanco et al., 2022).

Supplying a high-quality public transportation service also involves guaranteeing accessibility and safety conditions in the systems, protecting vulnerable populations such as women, children and minorities (Scholl, Fook, & Barahona, 2022). Insecurity in public transportation increases the demand for private trips and ride-hailing (Oviedo et al., 2022). Measures implemented to promote accessibility and safety for these social groups include reserving vehicles and sections of carriages for women, funding awareness campaigns against harassment on public transportation, using technology to call for help or report incidents, and building and improving mobility infrastructure to ensure safer and more accessible journeys (Allen, 2018). Examples of these measures are found in London (Transport for London, 2016), Delhi (India), Bogota (Colombia), Manila (Philippines), and Mexico City (Mexico) (Allen, 2018; Scholl et al., 2022).

Safety is a dimension of transportation service quality.

The promotion of active transportation requires urban planning, investments in infrastructure, and integration with other transportation modes. Planning oriented towards the design of complete, multimodal and inclusive streets, as well as mixed land use for the development of "15-minute cities" favor active transportation and road safety. The TOD approach and integration between walking and cycling with access to public transportation favors the use of more sustainable transportation modes (Scholl et al., 2022). Key factors for successful results include connecting pedestrian and bicycle paths with public transportation stops, providing pedestrian infrastructure where cars cannot travel or park, allocating bicycle lanes, intersections management, and improving public spaces with infrastructure adapted to people with reduced mobility (Ardila-Gomez et al., 2021). In the United Kingdom, a significant association was found between infrastructure expansion for active modes and mode shift away from the car (Song et al., 2017). In the Netherlands, Denmark and Germany, the provision of segregated bicycle lanes and traffic calming infrastructure proved to be the most effective measures for bicycle promotion (Pucher & Buehler, 2008). In addition to infrastructure investments, the promotion of applications incentivizing the use of active modes of transportation has positive effects on the mode shift from the private vehicle to the bicycle, as demonstrated in the Netherlands (Huang et al., 2021). Regarding road safety, compact and connected cities can reduce traffic fatalities, as urban design reduces the need to use a car, encouraging shorter journeys. A study using traffic fatalities data in 50 US states, Washington DC, and Puerto Rico reveals that, for every 1% shift towards a more compact and connected urban configuration, the fatality rate for all modes of transportation drops by 2.26% (Ewing & Hamidi, 2015).

The supply of transportation services for first and last mile trips facilitates the mode shift towards active transportation and its integration with public transportation systems (Scholl, Fook, & Barahona, 2022). Public bike-sharing systems and other forms of micro-mobility are becoming more widespread. The effect of bike-sharing services on public transportation demand is positive when bike stations and public transportation stations are close enough to each other (Wu et al., 2020). In the case of Helsinki, bike-sharing contributed to increased demand for public transportation and reduced travel times by six minutes (Jäppinen et al., 2013). The integration of payments and information is key in this regard, in order to facilitate multimodality and reduce waiting times. In San Antonio, Texas, the Transit App is an example of how San Antonio BCycle and VIA Metropolitan Transit were integrated into a single app, allowing users to plan a multimodal trip, purchase a transit pass, and unlock a bike in just a few steps (MassTransit, 2022).

Regarding private transportation and pricing instruments, congestion charges and road charging have been relatively successful in reducing car use, despite difficulties in their implementation. Successful experiences include London, Singapore, and Stockholm, achieving reductions of 13% to 30% in congestion and 15% to 20% in GHG emissions (Pike, 2010). Public acceptance is a crucial factor for the successful implementation of congestion pricing schemes. Stockholm and Norway showed that public opinion can significantly shift in favor of the scheme when revenues are invested in transportation projects that benefit users, such as improving public transportation, parking and access facilities to public transportation (aka park-and-ride), and the construction of new infrastructure (Selmoune et al., 2020). Additionally, the workplace parking fee –applied to employers who provide parking– implemented by Nottingham in 2012, has raised USD 111 million over 10 years, which have been reinvested in sustainable transportation throughout the city (Nottingham City Council, 2022). Other demand management measures listed in the “Avoid” pillar also contribute to mode shift, reducing car usage.

Fossil fuel taxes, also known as carbon taxes, the elimination of gasoline subsidies, and taxes on internal combustion vehicles are the most effective instruments to reduce CO2 emissions, as they directly target the carbon content of energy sources and stimulate the use of more energy-efficient and sustainable modes. Carbon taxes, implemented at the national level, can be implemented as a tax or through an emissions trading system (ETS), which increases the relative price of polluting energy sources (World Bank, 2021c). Estimates for the Netherlands suggest that raising the fuel tax by 10% leads, in the long term, to a fall in fuel consumption (and therefore CO2 emissions) of up to 8% for passenger vehicles and 3% for cargo vehicles (KIM, 2018). In Sweden, an assessment of the carbon tax impact on CO2 emissions from passenger vehicles reported a 6% reduction in such emissions (Andersson, 2017). In the region, Chile has also developed a carbon tax to internalize

Congestion charges and road pricing incentivize modal shift.

environmental costs (Box 4.5). Vehicle taxes, on the other hand, consist of levies collected at the time of registration or purchase of the vehicle, or periodic charges for vehicle use or ownership. These taxes are, in many cases, directly or indirectly related to their emission levels by being indexed to characteristics such as the year of manufacture and engine technology, and have been shown to have an impact mainly on vehicle purchasing decisions. In the Netherlands, the price elasticity of vehicle demand was estimated in -0.5, indicating that a 10% tax on the price of the vehicle reduces the demand for vehicles by 5% (KIM, 2018). Linking vehicle taxes to their CO2 emissions is an effective way to promote the technological uptake of the vehicle fleet (Runkel et al., 2018). Although these measures are fundamental to reduce emissions, their implementation proves to be politically and socially difficult in some countries. Therefore, their design and implementation must be carefully communicated to ensure social acceptance. As evidenced in the case of Quebec, acceptance can be increased by allocating the collected resources to the improvement of public transportation quality, which also encourages mode shift (Gouvernement du Québec, 2018).

BOX 4.6.

Green tax on mobile sources in Chile: Impact assessment

As a strategy to limit the negative impact of the vehicle fleet on the environment, Chile enacted the so-called Green Tax on Mobile Sources on December 19 of 2014. This tax affects new motor vehicles intended for private transportation with a capacity to carry less than nine passengers, and is paid only once at the time of the first purchase. Vans of up to 2,000 kg of load capacity and taxis are exempt. The tax is calculated based on the level of NOx emissions, urban efficiency (km/liter), and selling price of the vehicle. Price & Gómez-Lobo (2022) estimated the causal effect of this tax on the average NOx emitted by new vehicles sold each year, finding that the tax has reduced the average grams/km of NOx in the diesel fleet by 18%. The results are encouraging and suggest that in order to increase the environmental impact of such policies, consideration could be given to including other polluting gases such as CO2 in the tax calculation formula, as Norway and Israel have done.

Parking control and pricing policies, limited traffic zones (or low-emission zones), and restrictions on vehicular access reduce car use and pollutant emissions. These measures include removing parking spaces in and around the city center, introducing car-free days, modifying traffic routes, and developing new cycle paths and pedestrian infrastructure. Oslo is a success story with the implementation of its parking and traffic control program to increase walking and cycling infrastructure, having achieved reductions in car trips between 11% and 19% (Figg, 2021). In addition to these types of regulations, governments can incentivize mode shift by raising climate awareness and rationalizing car use. One of the most popular initiatives is the car-free day that has been implemented by several cities around the world, reporting significant improvements in air quality. For example, the first car-free day in Paris, held in September 2015, reported a reduction of 40% in emissions from vehicle exhausts (UNEP, 2018).

Traffic restriction measures are helping reduce air pollution in cities. Various urban vehicle access regulations are in place to reduce air pollution and road congestion. Low Emission Zones (LEZ) are one example, in which vehicle access to a defined geographical area, such as a city, is limited by a regulation. In Europe, an estimated 265 cities have adopted some form of LEZ (Bernard et al., 2020). In the case of Brussels, the introduction of a LEZ in January 2018 was associated with a reduction of 4.7% in NOx emissions from cars and a reduction of 6.4% in PM2.5 emissions due to reduced traffic and fewer older and more polluting vehicles. These emission reductions were observed in the comparison of a representative week from June 2018 with one from December 2018. (Bernard et al., 2020). In London, the ultra-low emission zone reduced NO2 concentrations, while the low-emission zones of Berlin and Munich reduced PM10 concentrations (Kim & Mason, 2023). In addition to LEZs, which focus on reducing air pollution, other policies –such as land use planning as a means of demand management– also help address air pollution in conjunction with other transportation objectives[14].

14 For more details, see Li et al. (2020).

4.2.1.3. "IMPROVE" PILLAR

"Improve" directly impacts urban transportation decarbonization by focusing on vehicle design, energy efficiency, and clean energy sources for both passenger and freight vehicles. The promotion of electric mobility is the group of measures with the most significant impact within the pillar. Electric vehicle sales have grown exponentially in the last decade. While in 2012 barely 120,000 units were sold, in 2022 these reached 10 million and this growing trend is expected to continue in the coming years (IEA, 2023a). The penetration of electromobility in the markets has been led mainly by China, Europe, and the United States, although other countries such as India, Thailand, and Indonesia have made significant efforts in recent years to promote electromobility in their markets. The most important policy instruments for driving technological uptake and energy efficiency in urban mobility systems are described below.

Major advances in the electrification of the automotive fleet are being driven by plans and regulations for the adoption of low- and zero-emission vehicles in light and heavy-duty vehicle fleets, and by vehicle emission standards. These plans, normally developed at the national level, define sales and production goals for zero- and low-emission vehicles, develop roadmaps for the automotive industry, and establish maximum emission levels to reduce their GHG and harmful gas emissions. In the United States, the Inflation Reduction Act includes tax incentives and funding programs to encourage the energy transition of the US economy towards clean energy, and focuses on stimulating electromobility through the allocation of funds to promote the sector. Additionally, the Advanced Clean Cars II Rule adopted by California, Vermont, Washington, and Oregon states that 100% of vehicles sold after 2035 must be zero emissions. The EU, in its Fit for 55 strategy, determines that CO2 emissions in cars and vans must be reduced by at least 50% and 55% for 2030 (compared to 2021), and by 100% for 2035 (European Council, 2023). In China, the Industry Development Plan 2021-2035 set a goal that, by 2025, 25% of vehicle sales will be electric or hybrid. In LAC, Chile announced in 2021 its goal of reaching 100% sales of zero-emission light vehicles by 2035. Regarding initiatives focusing

The promotion of electric mobility is present in all the reference countries.

on freight vehicles, Drive to Zero links cities, national and regional government agencies, fleet manufacturers, fuel/energy suppliers, and other organizations to establish collaboration and support mechanisms that accelerate technological upgrading of the freight fleet. By 2022, a total of 27 governments had committed to achieving 100% sales of zero-emission buses and trucks by 2040 (Global Commercial Vehicle Drive to Zero, 2023). Other national strategies to achieve technological upgrading in the freight fleet are found in Canada with the 2030 Emissions Reduction Plan, in Chile with the National Electromobility Strategy of 2022, and in China with Stage VI of the emissions standard for heavy duty vehicles. Importantly, this regulation should also cover imports of used vehicles and the full cradle-to-grave[15] cycle of electric vehicle emissions, as evidenced in France, Italy, and the United Kingdom (Schuller & Stuart, 2018).

The formalization of paratransit[16] is a fundamental step for its inclusion in technological uptake strategies. The relevance of paratransit is recognized in contexts such as India, where three-wheeled vehicles (known as "tuk tuk") play an important role in the provision of passenger transportation services and have great potential in the decarbonization of the sector, given the large number of existing vehicles and their low emissions per passenger transported and km traveled compared to cars (ITF, 2023b). The presence of these services is also growing in LAC (Scholl, Fook, & Barahona, 2022). Examples of formalization and electrification are found in the Philippines and Rwanda. In the Philippines, the Department of Transportation professionalized minibus and Jeepney services and formalized them through paid operating contracts based on traveled kilometers and level of service. In Rwanda, the electrification of the motorcycle taxi service was achieved thanks to public-private collaboration models (Briceno-Garmendia et al., 2022; ITF, 2023b).

15 This considers, among other things, vehicles battery manufacturing. Due to its high energy demand, battery manufacturing can increase the carbon footprint in the production process of electric vehicles.

16 Paratransit -also known as semi-formal and informal services, although operators are not always informal businesses– refers to flexible, unscheduled, demand-driven public transportation services provided by small, self-organized operators, in small- to medium-sized motor or non-motorized vehicles, usually without an adequate regulatory framework (Jennings & Behrens, 2017).

An important regulation in the transition to zero-emission vehicles concerns minimum standards in vehicle emission technologies and fuel quality rules. Along with the standards on maintenance and periodic review, these are instruments available at the national level to improve vehicles' internal combustion efficiency, optimizing energy expenditure and reducing harmful pollutant emissions, which deteriorate air quality. The European definition of emission standards has classified vehicles into six categories according to their emission level, currently reaching the most demanding level in terms of combustion efficiency, corresponding to Euro VI (defined in 2015). By mid-2025, cars within the EU will have to comply with Euro VII level and, by mid-2027, buses and trucks will have to comply as well. Under the current Euro VI standard, emission levels for NOx, CO, PM, hydrocarbons, methane, and ammonia are defined for trucks and buses. In addition to the currently regulated pollutants, the proposed regulation for the Euro VII emissions standard would also regulate ammonia limits for cars and vans, the levels of formaldehyde, nitrous oxide, and the level of ultrafine particles up to 10 nanometers, present in brakes and batteries (European Commission, 2022). Outside Europe, countries such as the United States, Japan, Brazil, China, Colombia, India, and Argentina have designed their emission policies following European standards (SLOCAT, 2021b).

Urban mobility decarbonization is mainly being driven by subsidies for zero- and low-emission vehicles, mostly buses[17]. Governments have extended support to public transportation operators to access zero- and low-emission buses and charging infrastructure through subsidies. In some cases, the subsidy amount fully or partially covers the incremental cost of electric buses compared to internal combustion buses. For example, Transport Scotland's Ultra-Low Emission Bus Programme provided support for the purchase of new ultra-low emission buses up to a maximum of 75% of differential costs with respect to diesel buses, in addition to supporting the infrastructure for this technology by up to 75% of the capital cost. This was done through two rounds of the program during 2020 and 2021 (USD 67.3 million). The level of support provided for the purchase of new buses depended on their ability to operate with zero emissions (Transport Scotland, 2023). Financial incentives for electric mobility also cover urban logistics. In

17 For financial instruments associated with private vehicles, see Section 4.3.

There are numerous programs to encourage the replacement of combustion buses for electric ones.

particular, subsidy schemes for the purchase of electric bicycles for freight transportation are widespread in countries such as Austria, Italy, the Netherlands, Germany, Belgium, the United Kingdom and France. In addition, subsidy programs cover light commercial vehicles in countries such as Canada, the United Kingdom, Ireland and the Netherlands. At the urban level, there are also programs in this area. For example, the Madrid City Council has in place the so-called *Cambia 360* aid plan, which includes different subsidy lines with an appropriation of EUR 110.8 million for the years 2021, 2022, and 2023. The budget contains a EUR 67.5 million support package for sustainable mobility, which includes assistance for the purchase of personal mobility vehicles such as bicycles and electric scooters, private vehicles, goods vehicles, buses, and electric charging infrastructure.

Monetary incentives for decarbonization also benefit the electric vehicle production chain. They cover both support for the production of electric vehicles in general, and the production of batteries in particular. India, for example, has approved schemes to support battery sharing and the development of electric vehicle manufacturing capacity, as well as for battery supply (IEA, 2022b). The US Bipartisan Infrastructure Act authorizes $3 billion for a subsidy program to support the development of the domestic battery materials processing industry and another $3 billion for battery manufacturing and recycling (DOE, 2022). In addition, grants are included for the Department of Energy to fund projects demonstrating the safety and reliability of using used electric vehicle batteries for energy storage and grid resilience. In addition to direct subsidies, governments have developed other financial incentives for the electric vehicle automotive industry. China and California have implemented regulations requiring automakers to produce a specific level of low- and zero-emission vehicles to take advantage of existing tax incentives. Both regimes stipulate that manufacturers maintain a certain level of “credits” generated by the sale of such vehicles, which provides incentives for overproduction and generates the sale of surplus credits to automakers that do not meet targets (New Climate Institute & Climate Analytics, 2020).

Public procurement is playing an important role in the decarbonization of urban mobility. Different cities have implemented innovations in public transportation bidding processes in order to increase competition and reduce the risk that new propulsion technologies may pose. For example, in Santiago, Chile, a new strategy for the organization of systems was developed, based on the separation of obligations related to the transportation service. On one hand, the figure of suppliers was established, who are responsible for the acquisition and provision of buses. On the other hand, the figure of operators was maintained, whose obligations were reduced to the provision of passenger transportation services. Both types of actors are linked through contracts with each other and with the State. These contracts establish the terms of use of the buses, the distribution of maintenance responsibilities, and fleet guarantees, among other aspects. With these criteria, companies from the electric sector were allowed to enter the market as fleet owners. Likewise, the specifications established incentives for the purchase of more environmentally friendly buses, such as extending the contract from 10 to 14 years for electric buses in Santiago and including energy efficiency of buses as a weighting factor in the technical score for biding offers (Navas et al., 2020).

Public investment in urban mobility decarbonization has focused mainly on charging infrastructure, in addition to including direct investment in the vehicle production chain and investment in R+D. The availability of an extensive public charging infrastructure network contributes to speed up the adoption of electric mobility. In this regard, countries have deployed significant investment programs in charging infrastructure. For example, under Phase 2 of the Faster Adoption and Manufacturing of Electric Vehicles Program, India's Ministry of Heavy Industries installed 2,877 charging stations in 68 cities, in addition to the 427 charging stations installed during Phase 1 (Ministry of Heavy Industries, 2021, 2022). Importantly, investments in charging infrastructure networks must have a clear and transparent process favoring their deployment, and also be implemented under a joint approach between different stakeholders, such as municipalities, the private sector, and utilities. Public investment also includes the production chain of electric vehicles. Indonesia Battery Corporation is an Indonesian state-owned manufacturer incorporated in 2021 with a USD 17 billion investment, whose production target is up to 140 GWh of batteries by 2030, of which 50 GWh will be earmarked for export (IEA, 2022b). On the other hand, countries have also made progress in investing in R+D in the subsector. For example, the US Bipartisan Infrastructure Act includes USD 60 million for R+D on logistics and battery processing costs reduction (DOE, 2022). In the EU there are several R+D initiatives related to urban mobility, such as 2ZERO, CCAM, Clean Hydrogen, Europe's Rail, DUT, Urban Innovative Actions, EIT Knowledge and Innovation Community on Urban Mobility, living.eu, and Smart Cities Marketplace that, together, accelerate innovation for sustainable and livable cities (European Commission, 2021b). In particular, the EU Climate Neutral and Smart Cities initiative (2021- 2027) is a promising approach to coordinate these efforts, by including funding opportunities for R+D, combined with new forms of governance and collaboration while involving citizens (European Commission, 2022).

Public transportation operators are making significant investments to advance the decarbonization of their fleets. A significant case is that of the city of Madrid, whose public operator, EMT Madrid, has renewed 62% of its fleet over the past four years, eliminating its last diesel bus in December 2022, and thus making Madrid the first large European city to have a 100% clean fleet according to the European Clean Vehicles Directive.

Behavioral incentives play a major role in the decarbonization of urban mobility, including energy efficiency measures and incentives for the adoption of electric vehicles. Within the promotion of energy efficiency measures, training in eco-driving stands out due to its fuel saving potential[18]. Norway has a comprehensive set of national policies addressing behavioral incentives for zero-emission vehicles, including free parking and opening of bus lanes for electric vehicle owners (in addition to the financial incentive of exemption from road tax) (Steinbacher et al., 2018). For its part, California allows the individual use of High Occupancy Vehicle (HOV) lanes for vehicles meeting certain emission standards (electric and plug-in hybrid vehicles) and other criteria (DMV, 2023).

Intelligent transportation systems (ITS) and smart mobility tools are affordable, fast, and effective instruments for mitigating urban transportation emissions. Investment in ITS, including transportation management centers and traffic management systems, contributes to the sector's emissions reduction, as experienced by the cities of Sydney, with

18 See details of eco-driving programs in Section 4.3.

Digital transformation is an ally in reducing emissions in the sector.

its SCATS intersection control system, and Shanghai, with its intelligent transportation services system (UNESCAP, 2019). The use of sensors and cameras makes it possible to measure the negative environmental externalities of vehicles more accurately with up-to-date information, and design appropriate instruments for their internalization, such as charges for pollutant emissions. Also, these intelligent systems allow real-time monitoring and control of traffic, to achieve greater compliance with regulations such as restricted vehicle access zones. In addition, data collected by these systems can be used to encourage shared trips, reduce time searching for parking lots, gas stations, or charging stations, mitigate road crashes and traffic congestion, and regulate the speed of vehicles. In logistics, telematics and telemetry systems can use GPS to optimize journeys, particularly last-mile trips, and reduce idling.

4.2.2. ADAPTATION MEASURES

Although urban mobility strategies have been focused on reducing emissions within the framework of the "Avoid-Shift-Improve" approach, planning instruments have begun to include adaptation to CC. For example, the London Transport Authority, TfL, has a CC Adaptation Plan that identifies key actions and areas for improvement to make the transportation network better suited and more resilient to CC, while contributing to a net zero emissions system and improving air quality (TfL, 2023). Planned actions include weather forecasting and warning systems, emergency responses, pumps to evacuate flood water, making climate projections, revision of standards and specifications to incorporate adequate requirements in tenders, incorporation of adaptation measures such as green infrastructure and rainwater collection, and business and asset strategies that incorporate adaptation. The Transportation Climate Adaptation Plan of the Sacramento region in the US also establishes specific adaptation measures for sustainable mobility, identifying actions for the planning, design, and maintenance stages of public transportation, active transportation (walking and cycling), and traffic management in the face of extreme weather events (SACOG, 2020). In addition, for the implementation of specific actions, the Plan identifies four major strategies that include infrastructure maintenance and management, reinforcement and protection of existing and new infrastructure, increase of redundancy (identification and creation of alternatives to vulnerable routes), and relocation or abandonment of infrastructure located in highly vulnerable areas. On the other hand, given the powers of municipalities in terms of territorial planning and transportation planning and management, the local level plays a key role in promoting CC adaptation measures. This is recognized in New Zealand's NAP and in the attributions of municipalities in Finland (CASCADE, 2019). Municipalities also play a major role in green infrastructure and nature-based solutions (NBS) development. For example, for climate adaptation, all municipalities in Denmark must conduct a flood risk assessment and climate adaptation plan, as determined by a national mandate that emphasizes the critical role of blue and green infrastructure, such as sustainable drainage systems (Danish Business Authority, 2019 in Nordh & Olafsson, 2021).

Regulations for the provision of infrastructure at the urban level have made progress in improving infrastructure resilience to CC. A relevant aspect in this regard is the establishment of design norms and standards to reduce the effects of extreme temperatures and precipitation. Thus, for example, the use of cool pavements that absorb less sunlight than conventional ones helps reduce surface and air temperature in cities, mitigating the heat island effect and contributing to promote active mobility. The use of cool pavements has been the subject of legislation in California, through Assembly Bill 296 (Cool Pavements Research and Implementation Act) (H. Li et al., 2016). As part of flood management, Wales has set standards for the development of sustainable drainage systems covering the design, construction, operation, and maintenance of systems in new urban and rural developments (Welsh Government, 2018). Some countries have made progress in regulating NBSs, including setting targets for access to green areas and regulations on specific solutions. For example, the City of Los Angeles has set a goal for at least 75% of residents to live within half a mile (800 meters) of a park or open space by 2035, rising to 100% by 2050, while Lisbon has set a goal for 90% of residents to live within 300 meters of a green space larger than 2,000 m2 by 2030 (C40 Knowledge Hub, 2021). Similarly, in 2009 the city of Toronto passed an ordinance requiring and regulating the construction of green roofs for new buildings or extensions of more than 2,000 m2, with requirements that vary between 20-60% of the available surface area (City of Toronto, 2023).

The use of price measures, non-financial instruments, and government procurement is still scarce. There is an incipient interest in exploring the use of subsidies for the development of NBSs, also using blended finance (White House, 2022). In this sense, as part of its strategy to reduce the heat island effect, the City of Chicago has provided incentives for the adoption of green infrastructure, such as rain gardens and permeable pavements, through an accelerated Green Permitting Process and funding for small projects (EPA, 2023). In Germany, in support of NBSs for green buildings, financial subsidies are provided for green facades and roofs (Mcquaid et al., 2022). With regard to non-financial incentives, training plays a significant role in CC adaptation. The State of Victoria, Australia, in its Transport Climate Change Adaptation Action Plan, which includes public transportation and active transportation, establishes capacity building for its personnel through training in adaptation (mitigation and maladaptation) (Victoria State Government, 2022). The importance of CC for the urban mobility sector is also beginning to be pointed out in public procurement processes. For example, Ireland's Transport Climate Change Sectoral Adaptation Plan states that public transportation service providers should consider the health and welfare of passengers in extreme weather conditions (heat or cold waves) in future business continuity management processes (DTTAS, 2019).

On the other hand, it is possible to identify a significant deployment of investments in adaptation of urban mobility, mainly focused on infrastructure. In the case of physical infrastructure measures, traditional measures (known as "gray" infrastructure) and NSBs (known as "green" infrastructure) stand out, with the former being the most widespread. Adaptation measures corresponding to traditional infrastructure include the maintenance and management of assets to protect them from the effects of CC, as well as new technological developments, such as flood control systems for metros or cooling systems to reduce temperatures in subway networks. For example, after the impacts of Hurricane Sandy in 2012, the New York Metropolitan Transportation Authority made significant investments to install floodgates in different subway stations for flood containment. TfL is testing a state-of-the-art cooling panel to reduce temperatures in the metro network, including tunnels and platforms at deeper stations (TfL, 2022). EMT Madrid is installing photovoltaic roofs from the parking bays of its buses in the operations centers (garages), with a double advantage: generation of renewable

The adoption of NBS is gaining momentum as a CC adaptation measure.

electricity and reduction of direct insolation on the facilities and the fleet, also reducing the air conditioning needs of the buses. In addition, NBSs can play a critical role in reducing vulnerability of urban mobility systems. For instance, in Ljubljana, Slovenia, green areas were developed to promote cooling, improving the quality of active mobility (Oppla, 2023). In addition to infrastructure, adaptation measures also cover urban mobility services and operation. The measures are mainly associated with real-time information systems and travel planning tools, to prepare the urban mobility sector for the occurrence of extreme weather events. In Tatabanya, Hungary, for example, they developed a local heat and UV warning system to deal with urban heat waves, which alerts citizens quickly and through different mechanisms, allowing them to prepare for the heat wave and plan their trips (Climate Adapt., 2023).

Table 4.1 summarizes the actions to mitigate and adapt urban mobility according to these instruments. These actions are discussed below, using the "Avoid-Shift-Improve" approach.

TABLE 4.1. Urban mobility policies implemented at international level*

Levels	Mitigation			Adaptation
	Avoid	Shift	Improve	
Plans / strategies	• National and local sustainable mobility plans, coordinated with each other and with NDCs and SDGs • TOD plans • Labor market policies (remote work, flexible working hours)	• TOD plans • National and local sustainable mobility plans, coordinated with each other and with NDCs and SDGs	• Electric mobility plans • Transition strategy to promote the use of cleaner technologies and fuels	• Mapping and vulnerability assessment of urban infrastructure • Early warning systems and emergency plans • National and local sustainable mobility plans coordinated with UNFCCC documents • Urban mobility infrastructure planning considering different climate risks • Redundancy of the urban mobility system by offering alternative routes • Avoid the development of new urban infrastructure in high-risk areas • olicy framework for NBS implementation
Regulations	• Shared mobility to circulate during restricted hours • Schedules and areas for loading and unloading operations	• Car-free days • Management of the parking supply • Vehicle circulation restrictions • Instruments for land value capture	• Regulations on low- and zero-emission vehicle uptake • Fuel quality regulation • Vehicle emissions regulation • Paratransit regulation and integration	• Development of appropriate design features and revision of technical construction standards (drainage systems, etc.) • NBS regulations
Public procurement	N/A	N/A	• Green public procurement (public transportation, waste collection, public fleets, shared public bikes)	• Design standards of the public transportation fleet as part of public procurement (e.g., units that withstand high temperatures)
Pricing instruments	• Congestion charges • Dynamic pricing for parking in commercial loading and unloading zones	• Road pricing (congestion, distance, etc.) • Fuel taxes • Car tax	• Subsidies for electric mobility (supply and demand subsidies) • Tax incentives in electric vehicle production chains	• Subsidies or tax cuts for adaptation measures (e.g. implementation of green roofs to reduce urban heat island effect) • Use of insurance (e.g. insurance bonuses subject to improvements in the maintenance of existing infrastructure)

TABLE 4.1. **Urban mobility policies implemented at international level**

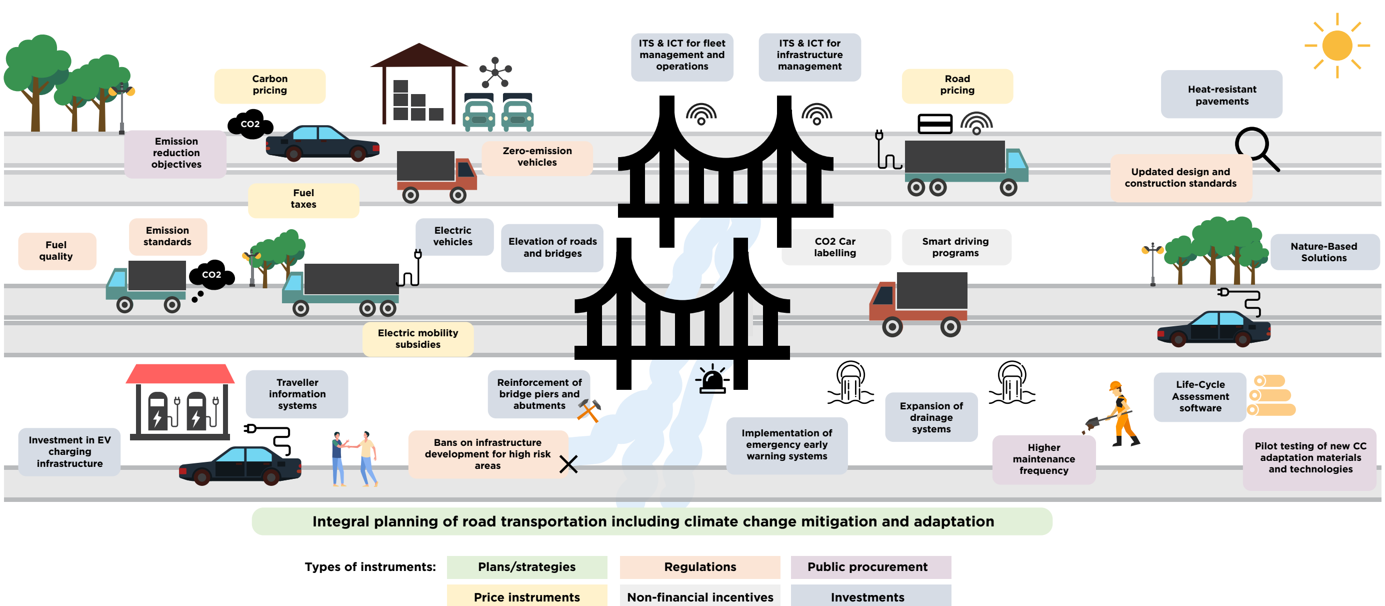
Levels	Mitigation			Adaptation
	Avoid	Shift	Improve	
		• Parking pricing • Supply/demand subsidies in public transportation • Public transportation vouchers for employees • Incentives to use active transportation in the form of points		
Non-financial incentives	• Awareness campaigns on the benefits of sustainable mobility	• Special vehicles for women, children, people with reduced mobility, and minorities • Awareness campaigns on the benefits of sustainable mobility	• Exemption from traffic and parking restrictions for electric vehicles • Eco-driving programs	• Training for planning departments of urban mobility agencies
Investments	• Infrastructure to reduce demand for motorized travel (dedicated lanes for vehicles with high occupancy)	• Public transportation infrastructure (dedicated lanes) • Infrastructure and services for the promotion of active transportation • Operational information systems for operators and users	• Investment in electric vehicle production chains • Investment in charging infrastructure for electric vehicles • Investment in electric buses • Investment in R+D of low emission technologies	• NBS development (sustainable urban drainage systems, development of green areas to respond to extreme temperatures, sand dunes to prevent coastal flooding due to rising sea levels, etc.) • Adaptation of operations and maintenance to respond to extreme weather events (e.g. implementation of cooling solutions to reduce the temperature in the metro network, provision of services adjusted according to extreme events, increased maintenance of green infrastructures, etc.) • Real-time information and trip planning tools

Source: Prepared by the authors.
Note: *Non-exhaustive list of policies. Some of the mitigation policies contribute to the achievement of more than one of the "Avoid-Shift-Improve" pillars.

4.3.
Measures for road transportation decarbonization and adaptation

Advancing in the decarbonization and adaptation of road transportation to CC requires a comprehensive approach, including measures in different policy areas for this subsector and in coordination with other government sectors. This subsection identifies successful measures implemented by benchmark countries in different action areas. However, these measures should not be considered in isolation; rather, successfully achieving decarbonization and adaptation objectives requires a combination of policy measures and a joint approach to them (Figure 4.3).

FIGURE 4.3. **Road transportation decarbonization and adaptation***



Source: Prepared by the authors
Note: *Non-exhaustive list of measures

• 4.3.1 MITIGATION MEASURES

Mitigating emissions from road transportation is essential to advance the decarbonization of the sector. Over the past three decades, CO_2 emissions from global road transportation have increased by more than 80%, amounting to 74% of the sector's total emissions (IEA, 2022g). In the region, road transportation is responsible for more than 90% of transportation emissions (IEA, 2022g). In this sense, emission reduction strategies aimed at road transportation have great potential to reduce the sector's impact on CC.

Benchmark countries' national plans and transportation strategies recognize the importance of road transportation for decarbonization. Some countries have set specific emission reduction targets. For example, in its 2030/2040/2050 plan, the UK Roads Authority sets a target of achieving zero emissions by 2030 for the authority's emissions, 2040 for maintenance and construction operations, and 2050 for road traffic (National Highways, 2021). Progress is also being made in establishing strategies at the subnational level. For example, under the Bipartisan Infrastructure Act, the United States created the Carbon Reduction Program to fund projects that reduce CO_2 emissions from road transportation. The Program requires each State to develop a carbon reduction strategy for this mode no later than two years after its entry into force, in addition to updating this strategy at least every four years (FHWA, 2023). An additional measure to advance in decarbonization has to do with improving the integration of road transportation with other modes –such as maritime and rail transportation–, as well as integrating long-distance freight transportation with urban freight transportation. For example, the UK's Transport Decarbonization Plan specifically addresses multimodal decarbonization and key drivers (Department for Transport, 2021b).

Regulations play a key role in decarbonization by providing guidelines for fuels, vehicles, and infrastructure. Benchmark countries have a wide range of regulations, including the improvement of fuel quality, vehicle emission standards, and regulation on the pricing of road infrastructure (Box 4.7), which have allowed progress in reducing emissions in the sector. The EU Fuel Quality Directive 2009/30/EC set a reduction target of at least 6% in GHG intensity by 2020, ensuring that the target is respected after, while regulating the sustainability of biofuels (European

Commission, 2023a). The GHG intensity of fuels is calculated based on their entire life cycle (extraction, transformation and distribution). Regulations on production standards and targets for the vehicle fleet are present in different latitudes, including the EU (Regulation 2019/631), New Zealand (Clean Car Standard and Clean Car Discount, which are mandatory since the Clean Vehicles Act of 2022), the state of California (Advanced Clean Cars II), and also in the region (Box 4.8). In the EU, the implementation of CO2 emission standards for light vehicles tripled the percentage of electric vehicles and led to a 12% reduction in average CO2 emissions per km of new units registered in 2020, compared to the average emissions of vehicles registered in 2019 (European Commission, 2021a). California currently requires vehicle manufacturers to produce a percentage of hybrid or zero-emission vehicles, and will ban the sale of gasoline-powered cars starting on 2035. Similarly, in March 2023, the EU approved a new regulation that will prohibit the sale of new internal combustion vehicles starting on 2035, except for those with engines running on carbon-neutral synthetic fuels.

BOX 4.7.

Alternative fuels

Transportation is significantly dependent on conventional petroleum-based fuels. Energy from oil and its derivatives represents 95.5% of the energy used in transportation worldwide in 2018, while the remaining 4.5% comes from biofuels and electricity (SLOCAT, 2021a). In road transportation, the energy solutions with the greatest potential to reduce GHG emissions are full-battery electric vehicles and hydrogen fuel-cell electric vehicles (between 60% and 70% compared to conventional cars over their lifetime) (ZEV Transition Council, 2021). However, reducing transportation to zero GHG emissions cannot be achieved with this single energy measure, especially in the short and medium term. For each transportation mode, public policies must deploy a set of favorable measures for the development of renewable energies and alternative fuels, in order to achieve the ambitious targets of sector decarbonization.

There are two main categories of alternative fuels: (i) biofuels, which are obtained from biomass through various production methods; and (ii) e-fuels, also known as electrofuels, power-to-X (PtX), power-to-liquid (PtL), or synthetic fuels, which are produced through an industrial process that converts electrical energy into chemical energy. E-fuels are divided into those containing carbon (e-kerosene or SAF, e-methanol) and those without (hydrogen, ammonia). Biofuels are already widely used in road transportation and are a promising avenue to contribute to the decarbonization of aviation and shipping. However, their scalability is limited by the amount of biomass that can be grown sustainably. Therefore, e-fuels can complement biofuels. They have fewer long-term scalability limitations, but are at a lower level of technological maturity than biofuels (ITF, 2023c). More generally, the viability of alternative fuels associated with a transportation mode varies depending on chemical properties, handling and storage requirements, and production costs.

• Biofuels

Biofuels account for more than 90% of renewable energy used in road transportation, and can reduce up to half of GHG emissions compared to fossil fuels (SLOCAT, 2021). However, biofuel production depends on the availability of raw materials (vegetable oils, cereals, forest or agricultural residues, etc.) for other applications, such as bioenergy for heating and electricity, or human food. This competition for uses can lead to problems of food security and soil and water availability, especially in low-income countries. Biofuels are also very sensitive to agro-climatic factors (crop yields, emission thresholds related to land-use change, etc.) and there are doubts about the sustainability of some feedstocks. The overall impact of biofuels on GHG emissions from transportation is low because they are often mixed with gasoline and diesel, which also impacts air quality. Cellulosic biofuels have greater potential, but are insufficient in the face of production needs. In aviation, biojet or SAF is a certified sustainable fuel, although it currently accounts for less than 1% of fuels used in the sector (IRENA, 2021).

• E-fuels

Drop-in e-fuels are alternative fuels compatible with existing technology and infrastructure systems. Non-drop-in fuels can be used in existing technologies with some adaptations, either in the engine itself, in the fuel supply system, or both. More energy options are viable or potentially viable for the decarbonization of the maritime sector, as will be seen in Section 4.4. E-fuels are also a pathway to the decarbonization of road transportation, although their production is even less widespread and more expensive than that of biofuels. Of particular interest to this subsector is the development of battery-electric heavy-duty vehicles, with electric cells and electrified roads. There are also already several pilots of heavy hydrogen vehicles. The consensus in advanced countries is to provide regulatory, technical, and financial support to multiple zero emission or net-zero emission solutions, avoiding betting on a single solution at a moment where technologies are being tested.

BOX 4.8.

Regulation on road infrastructure charging: Eurovignette Directive

Road infrastructure charging in the EU is regulated by the Eurovignette Directive, initially adopted in 1999 and revised in 2022 (Directive 2022/362/EU). The Directive's first objective is to prevent discrimination based on nationality in the way tariffs are applied to trucks crossing Union borders. The main amendment made in 2022 requires charges to be differentiated according to CO2 emissions. This will apply starting on 2024 for electronic charges per kilometer, which is the type of charge used in a growing number of EU countries. Likewise, for future concessions, the cost of tolls on concessioned freeways will be differentiated according to the CO2 emissions generated by different types of trucks. In general terms, these measures promote the "user pays" and "polluter pays" principles, which contribute to the internalization of the external costs of road transportation, such as those generated by infrastructure use and its social and environmental impacts (European Commission, 2023b). At the same time, these measures promote a more efficient use of infrastructure affected by congestion and constitute a source of revenue for the development of infrastructure and more efficient and cleaner modes of transportation.

TABLE 4.7.1.

Main features of the Eurovignette Directive on road infrastructure charging

Characteristics	Heavy duty vehicles[1]	Light duty vehicles[2]
Charging mechanism	• Starting in 2030, Member States that charge tolls on the Trans-European Transport Network (TEN-T) must base the value charged on distance traveled • Stickers for highway circulation (known as vignettes) allowed in other parts of the network	• Both tolls and vignettes are allowed

Environmental differentiation of the charge	• Mandatory differentiation of CO2 emissions (starting with the heaviest trucks)	• Optional environmental differentiation according to CO2 emissions and/or Euro emission standard
Pricing of External costs	• Mandatory external cost for air pollution • Voluntary pricing of external costs for noise and/or CO2 emissions	• Voluntary pricing of external cost of air pollution, noise and/or CO2 emissions
Congestion charge	• Voluntary charge that can only be applied on road sections that are regularly congested, and at times when they are congested	
Mark-up	• Additional charges to infrastructure charges (up to 50%) that may apply in any regularly congested or sensitive area	
Use of revenues	• Revenue from additional charges and congestion charges goes towards reducing congestion, reducing environmental damage, or developing sustainable transportation	

Source: Schroten et al. (2022a).
Notes: [1]HDV; [2]LDV.

BOX 4.9.

Chile's energy efficiency label instrumentation and Vehicle Control and Certification Center (3CV, for its abbreviation in spanish)

Vehicle efficiency labels are a key tool to improve the vehicle efficiency of new light duty vehicle fleets. Through its National Energy Strategy 2012 to 2030, Chile began the process of implementing an energy efficiency label for vehicles. The label was launched in 2012 on a voluntary basis but had very little participation, so in 2013 the government established it on a mandatory basis, covering the entire industry (Martínez Salgado & Castellanos, 2019). Likewise, a green tax on mobile sources was established through Law 20780 in 2014, which was linked to the label, based on vehicle performance, NOx emission levels, and the price of the vehicle (Ministry of Finance, 2014). In the process of implementing the energy efficiency label, the role of 3CV has been key, in addition to the participation of all relevant stakeholders.

In Chile, in order to circulate on public roads, all motor vehicles must prove that they comply with the technical standards established by the Ministry of Transport and Telecommunications. The 3CV, under the same Ministry, is the public body responsible for carrying out this accreditation, which consists of procedures that vary according to the type of vehicle (light, medium, motorcycle, and heavy). Additionally, 3CV has an evaluation role in the incorporation of new technologies applied to vehicles.

The accreditation process of light-, medium-, and heavy-duty vehicles and of motorcycles, called homologation, consists of a technical analysis verifying that each vehicle model entering the country complies with the required levels of exhaust gas emissions and hydrocarbons evaporation, as well as with safety, dimensional and functional requirements, including systems and components. Once the model has been approved, the applicant is authorized to grant Individual Approval Certificates (CHI) for each vehicle marketed.

To inform buyers about the performance and emission level of each vehicle, manufacturers, owners, marketers, distributors, or importers of vehicles must make a standard format label with the official values provided by the 3CV through laboratory tests carried out in locally designed driving conditions. The energy consumption label is important because it contains official and reliable information about fuel efficiency, allowing users to search and compare the various vehicles under the parameters of consumption and emissions.

After the vehicle enters circulation and to regularly validate the good condition of a motor vehicle and protect the environment, Chile has technical review plants distributed throughout the country, which annually review the condition of vehicles as part of the process to issue circulation permits. This review includes basic systems of the vehicles such as steering, brakes, suspension system and transmission, among others. Additionally, it is also a requirement to review compliance with pollutant emission levels, in order to safeguard compliance with emission standards.

All this regulation has allowed Chile to become an international benchmark in the homologation and technical review of vehicles, fundamental aspects to be able to plan, measure and project the impacts of the transportation sector on local and global emissions.

The public bidding system makes it possible to reduce CO2 emissions from road transportation through economic incentives and the requirement of technical standards. Transportation authorities have set different targets for public procurement in terms of emission reductions, including bonus and penalty schemes tied to target achievement. The Norwegian Public Roads Administration, as part of its project called KraKK regarding CC requirements in public procurement, includes carbon reduction criteria in the procurement of construction works, services and operations, and maintenance (Reeves et al., 2020). The objective is to reduce in 50% the carbon footprint of operation and maintenance, and in 40% the carbon footprint of investments by 2030, compared to 1990. To this end, contractors receive bonuses for using materials that emit less CO2 and for using machinery and vehicles that do not run on fossil fuels. Since 2016, the Swedish Transport Administration (Trafikverket) has been using the Klimatkalkyl emissions calculation tool to establish public procurement requirements for infrastructure projects (Reeves et al., 2020). Although the targets vary depending on the project, average emission reductions of 15% are expected for contracts ending between 2020 and 2029, and 30% for those ending after 2030.

Pricing instruments for road transportation emissions are widely used, although with significant differences in their scope. In general, it is possible to identify three types of taxes and charges depending on the basis they consider for their application: energy taxes (including CO2 taxes), vehicle taxes, and levies on infrastructure (CE Delft et al., 2019). In the EU, all member countries apply taxes on fuel, although tax levels vary considerably from country to country, with a lower tax overall for vans and heavy duty vehicles due to lower taxes on diesel relative to gasoline (Schroten et al., 2022a). In some countries, specific carbon or CO2 taxes are levied on road transportation as part of excise taxes on fuel. Moreover, in December 2022, the European Parliament and the Council of the EU agreed to establish a new Emissions Trading System (ETS II) that includes road transportation. The launch of the new regime is planned for 2027 and will regulate fuel suppliers rather than final consumers, imposing an absolute cap on emissions, which will decrease based on a linear reduction factor (ICAP, 2023). Allowances shall be distributed exclusively though auctioning.

Infrastructure charges help mitigate emissions from the subsector by

Trucks with zero- and low-emission technologies achieve carbon emission reductions of up to 63% compared to diesel technologies over the lifetime of the vehicle (O'connell et al., 2023).

The combination of pricing instruments increases the effectiveness of such measures.

reducing demand and increasing efficiency. Distance-based charges are widespread. Hungary is an example of the implementation of this scheme, where distance-based toll rates depend on the type of road used and the category of the motor vehicle, as well as its environmental classification (HU-GO, 2023). For its part, New Zealand applies this scheme to all heavy-duty vehicles and all light diesel vehicles, and on all public roads. Charges vary based on three factors including distance, vehicle weight, and axle arrangement, allowing rates to be estimated proportional to the likely average wear and tear a vehicle generates on roads. Additionaly, light electric vehicles are exempt from the charges until 2024 (Ministry of Transport, 2021). However, recent results for the Netherlands showed that the effectiveness of these charges depends on price sensitivity. While in passenger cars these charges can lead to a 20% reduction in CO_2 emissions, on heavy-duty and light commercial vehicles, a segment that is less sensitive to price variation, they would have a relatively minor impact of only 5% and 8%, respectively. (Schroten et al., 2022a). However, they would generate important incentives for logistics optimization, increasing consolidation and reducing empty trips.

The combination of pricing instruments increases the effectiveness of these measures. Fuel taxes (including CO_2 taxes) and emissions trading schemes are effective in reducing CO_2 emissions from road transportation, as they incentivize all possible decarbonization options (reduction in vehicle ownership, more fuel-efficient vehicles, shift to low-carbon energy carriers, efficient driving, increased transportation efficiency, mode shift to low-carbon modes, and limitation of the global transportation demand) (Schroten et al., 2022a). Indeed, carbon pricing policies (carbon taxes and emission trading systems) are considered the best instruments due to their efficiency, cost-effectiveness, and promotion of investments in clean technologies. In this regard, the details of policy design are important, as they should be comprehensive, allow revenue collection, and be used in a socially productive way (Krupnick & Parry, 2012).

The road freight transportation decarbonization policy is leveraged on the replacement and renewal of heavy-duty vehicles fleet by zero- and low-emission technologies. According to O'Connell et al. (2023), trucks with zero- and low-emission technologies can reduce carbon emissions by up to 63% compared to diesel technologies throughout the useful life of the vehicle. In this scenario, different governments have set goals for the renewal of the cargo vehicle fleet, while implementing incentive schemes for technological upgrades to zero- and low-emission vehicles through subsidies for the purchase of new units, import tariff reductions, tax reductions, investments in charging infrastructure, promotion of research and development, restrictions on the mobility of polluting vehicles, and circulation requirements. Examples of initiatives to subsidize vehicle purchases can be found in Canada, where the Incentives for Medium- and Heavy-duty Zero-Emission Vehicles program (iMHZEV) was launched in July 2022 with a budget of CA$547.5 million to subsidize the purchase or rental of medium- or heavy-duty cargo vehicles (Government of Canada, 2023). In France, the Green Bonus program offers subsidies of up to EUR 4,000 for cargo vans with a capacity of less than 2.4 tonnes and a value of less than EUR 60,000 (Ministère de l'Économie, des F. et de la S. industrielle et numérique, 2023). Regarding infrastructure investments, in 2021 the Bipartisan Infrastructure Act mentioned above was signed in the United States, providing USD 7.5 billion for investment in charging infrastructure (US Federal Highway Administration, 2023).

Non-financial incentives contribute to the decarbonization of the subsector through user awareness of the CO2 emission reductions. Vehicle labeling is a requirement aimed at vehicle makers and sellers so that consumers can visualize their energy efficiency, while encouraging producers to reduce new vehicles' fuel consumption. Labelling becomes more relevant due to the increase in taxes on CO2 emissions and the associated rise in fuel costs. In this sense, the EU Car Labelling Directive (Directive 1999/94/EC) requires labeling of fuel-consumption and CO2 emissions on new vehicles on sale to help users make informed decisions.

Another effective measure within non-financial instruments is eco-driving programs. Through a series of recommendations on how to drive vehicles, these programs manage to reduce CO2 and other gas emissions, while generating lower fuel and maintenance costs, plus other benefits such as the professionalization of drivers and greater road safety (Pineda & Xie, 2021). The reductions in consumption derived from this practice can reach values of up to 30%, which is also relevant for electric vehicles since it can increase their autonomy (BMK, 2021). The best practices in eco-driving training programs include the consideration of local aspects; a strong curriculum; partnerships with private and public stakeholders; the implementation of a pilot phase before scaling the program; flexibility in implementation methods; monitoring, evaluation and feedback mechanisms; and maintenance plans (Pineda & Xie, 2021). Canada and the United States are considered leaders in eco-driving by the SmartWay program, which provides tools for freight transporters to boost supply chain efficiency and reduce fuel consumption and emissions generation. These tools include SmartDriver, an eco-driving learning platform developed and maintained by Natural Resources Canada in consultation with road industry representatives (NRCan, 2023).

Business strengthening programs contribute to overcome road transportation decarbonization barriers. These programs can be of a general nature, such as those aimed at the entire SME sector –a size of company with a large presence in the subsector–, or specific, which are usually implemented in coordination with other government agencies, such as those of industry and science and technology. Road transportation companies can benefit from the boost that governments are giving to SMEs digital transformation, where one of the goals is to improve energy efficiency through this transformation. Measures adopted by countries such as the United States, France, and the United Kingdom include: (i) creation of technology centers that bring together leading companies, entrepreneurial ecosystem and SMEs to develop and transfer technologies; (ii) implementation of programs to generate capacities around technological transformation in conjunction with sectoral and trade associations; (iii) generation of socialization networks where leading companies and SMEs can share experiences with their peers (Calatayud & Katz, 2019).

Public investment in mitigation for the road sector has been mainly associated with charging infrastructure, led by electric mobility. Public access chargers worldwide totaled 2.2 million at the end of 2022 –of which one third were fast chargers–, a 55% growth in total number of chargers over the 2021 stock (IEA, 2022a). In contrast, hydrogen refueling infrastructure is comparatively less developed than that of electric mobility, with nearly 700 hydrogen refueling stations deployed globally (IEA, 2022c). Deployment of a public infrastructure network of electric chargers and refueling stations is essential to ensure the availability of services on long-distance routes that keep pace with the growth of the vehicle fleet. In this regard, the European Commission reached an agreement between the European Parliament and the Council in 2023 to increase the number of electric recharging

Between 2021 and 2022, the electric recharging network grew by 55%.

and hydrogen refueling stations accessible to the public in the main transportation corridors and nodes of the EU. Proposed targets include the establishment of: (i) fast electric charging infrastructure for cars and vans in the Trans-European Transport Network (TEN-T) of at least 150 kW every 60km starting on 2025; (ii) recharging stations dedicated to heavy-duty vehicles with a minimum output of 350 kW installed every 60km along the core TEN-T network and every 100km on the comprehensive TEN-T network starting on 2025, with full network coverage to be achieved by 2030; and (iii) hydrogen refueling infrastructure –both for cars and trucks– deployed in all urban nodes and every 200km along the TEN-T core network starting on 2030 (European Commission, 2023c). For its part, in the update of its Investment Plan 2022-2023, California contemplates investments of USD 2.9 billion from the state budget that will be allocated over the next four years to recharging and refueling centers for clean trucks and buses (California Energy Commission, 2023).

Hydrogen is also recognized as part of the solution to replace fossil fuels in road transportation (IPCC, 2018). The hydrogen truck market is expected to continue growing globally, driven by regulations such as California's Advanced Clean Truck regulation and the Global Memorandum of Understanding on Zero Emission Heavy and Medium Duty Vehicles, by encouraging truck manufacturers to offer more zero- emission options (IEA, 2022c). The development of both types of technologies –electric and hydrogen– could translate into economic benefits. An analysis for the EU shows that a system based 100% on electric vehicles could cost between EUR 3 and 5 trillion more by 2050 than a combined system through reducing the risk of resource depletion and alleviating bottlenecks that could arise if only one technological option was considered (Clean Hydrogen Partnership, 2022). However, this would imply the development of different supply and recharging infrastructures for different energy sources, so further analysis of the net benefit of these options is required (ITF, 2022a).

In addition to the decarbonization of vehicles, decarbonization of road transportation requires adding construction, maintenance and road infrastructure operation to the equation. Required measures to achieve this goal include changes in materials and construction processes to reduce the energy required, recycling of materials, optimization of routes to minimize the energy involved in the transportation of materials and waste, preventive maintenance of pavements, and generation of renewable energy to meet the energy demand associated with lighting and signaling. In this sense, the US Federal Highway Administration has a detailed guideline to improve pavement sustainability, which summarizes the best practices to minimize energy consumption and emissions associated with the different stages in the useful life of roads (FHWA, 2015). An example of changes in materials is the use of warm asphalt mixtures, which have been widely used in the United States, Mexico, and South Africa to reduce energy consumption and emissions associated with road infrastructure construction. The production and application processes of this type of asphalt mixtures are carried out at temperatures of up to 40°C below those of conventional pavements, reducing energy consumption in the production process, facilitating construction processes, and increasing durability (PIARC, 2019a).

Aligning road transportation strategies with climate objectives requires considering carbon emissions throughout the entire life cycle of infrastructure, assessing its impact from the design phase. Thus, for example, in the case of asphalt pavement construction it is necessary to consider the carbon generated per km of road in the different stages: production and transportation of the material, as well as construction, operation, maintenance, and dismantling of road infrastructure (Box 4.9). The use of IT tools, such as life cycle assessment (LCA), makes it possible to assess the life cycle performance of roads and is implemented by national road authorities in decision-making. In Norway, LCA is carried out at the beginning of the planning phase by a cost-benefit software called EFFEKT. Sweden has Klimatkalkyl, which makes it possible to estimate GHG emissions and energy use associated with a project during construction, operation and maintenance. Similarly, the Netherlands has developed a tool called DuboCalc to calculate the environmental impact of a construction design over its lifetime (Reeves et al., 2020). There are also commercial solutions, such as ORIS, a digital platform that uses AI to assess infrastructure projects' energy consumption in order to reduce its carbon footprint.

BOX 4.10.

Evaluation of new technologies using LCA

The LCA methodology focuses on estimating a product's environmental impacts by tracing environmental exchanges (emissions, reagent consumption, and energy) throughout its life cycle. Sizing the carbon footprint associated with roads is of great importance within CC mitigation strategies since, for example, road construction contributes with more than 5% of GHG emissions in Europe. In the Netherlands, approximately 90% of the carbon footprint of asphalt roads is concentrated in production of raw materials, transportation of the materials to asphalt plants, and production of the asphalt mix (Bizarro et al., 2021). In the United States, cradle-to-gate emissions associated with the production of asphalt mixes accounted for about 0.3% of total US GHG emissions in 2019 (Shacat et al., 2022).

The use of LCA on roads facilitates the evaluation and adoption of new technologies such as asphalt mixtures with End-of-Life Tires (ELTs) or the recycling of pavements that have reached their useful life, allowing to estimate possible reductions in environmental impacts compared to conventional technologies. For example, when comparing the life cycle (extraction, mixing, construction, rehabilitation, and useful life of the work) of the same amount of asphalt mixture material modified with rubber powder versus an asphalt mixture modified with polymers (SBS), a 26.79% decrease in GHG emissions and 27.3% in energy consumption is perceived. Additionally, there may be a greater decrease in emissions and consumption considering that, for the same service, asphalt mixtures with rubber powder require a thinner layer thickness, resulting in a decrease in the exploitation of virgin materials, lesser transportation, and a longer useful life. A significant additional reduction in emissions can also be generated during construction due to lower compaction and mixing temperatures, with an environmental burden between 5% and 10% lower than that of the traditional technology. According to the life cycle assessment, the most significant GHG emission savings are achieved in the maintenance process (Wang et al., 2018).

On the other hand, if the LCA is carried out for deep recycling with

The use of LCA facilitates the adoption of new technologies.

material recycling compared to a virgin material, reductions of 39.5% in emissions and 38.4% in non-renewable energies consumption can be generated. The benefits of this technology are also found in the avoided effects, corresponding to the transportation of waste that would not be recycled and to the exploitation of the quarry for the acquisition of virgin material. Newcomb et al. (2016) provided an overview of the economic and environmental benefits of using recycled pavement, indicating that GHG emissions of up to 16% can be avoided in asphalt mix materials and in the construction process. In the United States, current practices related to the use of recycled materials and the type of fuel consumed in asphalt plants (some use gas) avoided emissions of 2.9 Mt during 2019, equivalent to the emissions generated by 630,000 vehicles. If the use of recycled pavement were to increase by one percentage point throughout the United States (for example, from 21.1% to 22.1%), this would represent 0.14 MtCO2eq in avoided emissions, equivalent to the emissions generated by approximately 30,000 passenger vehicles per year (Shacat et al., 2022).

In addition to the environmental effects described above, ELT-modified asphalt technology improves pavement structural performance and durability while facilitating water evacuation from the road surface. Besides, this technology is cheaper than other modifiers and allows the replacement of virgin polymers in asphalt modification. ELT-modified asphalt mixtures technology has begun to be implemented in the United States and Spain, and in LAC countries such as Chile, Mexico, Brazil, Colombia, Uruguay, Argentina, and also in Paraguay, where Law 6953 on the use of recyclable materials in road network works was approved in 2022.

Regarding the recycling of pavements that have reached their service life, recycled layers that are properly designed and subjected to strict quality control can perform as well as or better than layers made with virgin materials only. This occurs especially when there is increased layer thickness and/or addition of an extra structural layer. Currently, the use of recycled pavement in hot asphalt mixes is the most widely used method in the United States, where during 2021, 94.6 million tons of pavement were recycled and 95% of the asphalt mix recovered from old pavements was reused (National Asphalt Pavement Association, 2022).

ITS and ICT have significant potential to mitigate emissions from transportation services. Their use has been very successful in recent decades, providing solutions for road transportation in areas such as road safety and traffic management efficiency, while also having significant potential to contribute in reducing emissions and meeting climate mitigation targets (IRF, 2021). In benchmark countries, these technologies are making it possible to extend the life of roads and maximize the use of their capacity. Of special interest are infrastructure management systems: platforms that receive and process data from a multiplicity of sources, including sensors and cameras located in vehicles and roads, mobile devices, radars and weather stations, among others, producing information to improve vehicle flow and road safety, according to changing road conditions (Calatayud et al., 2022). The United Kingdom has implemented this system on the M42 motorway, one of its main thoroughfares, to manage traffic flow and lane use through variable message signals. Thanks to improvements in travel speeds and lower fuel consumption due to greater consistency of vehicle speeds, the system has reduced emissions by 10% (WEF, 2014). Similarly, data for the United States shows that V2I (vehicle-to-infrastructure) connection applications can reduce congestion by up to 27% and CO2 emissions by 11% (DOT, 2015).

While emission reduction strategies are mainly focused on technological change, there is growing interest in promoting mode shift. Rail transportation offers an alternative in this regard, with the emission intensity of rail freight being almost ten times lower than that of trucks (per tonne-km) (ITF, 2022b). Thus, the German Ministry of Economics

Promoting inter- and multimodality is part of the strategy to reduce emissions.

has estimated that a partial shift from road passenger and freight transportation to the rail system could reduce emissions by 18 MtCO2 (Donat, 2020). To encourage this transition, the German government has launched a master plan for rail freight, whose main tenets are to ensure high-capacity infrastructure, make extensive use of innovation potential, and improve the transportation policy framework (BMDV, 2017). In the case of the EU, it is estimated that switching from road to rail transportation for distances greater than 700 km –increasing the modal split of rail for freight transportation to 36%– could save 40 MtCO2 per year (ERA, 2023). For this reason, the shift to rail is one of the main pillars of the EU strategy to achieve the targets of the European Green Deal in Transport, identifying the need to connect Europe's main urban areas; connecting the 30 main airports to the rail network; developing a European network of night trains; removing rail bottlenecks; promoting an industrial railway policy; and financing railway projects (ERA, 2020).

Coordination with other government sectors must go hand in hand with the design and implementation of measures for the subsector. Road transportation decarbonization requires actions such as the use of energy that is zero emissions or net-zero emissions at its origin and distribution; the timely supply of such energy; science and technology, trade, and industry policies that make solutions locally available; and the training of the labor market in the use and maintenance of new vehicles, among others. Since these measures are usually the prerogatives of other government entities, benchmark countries in the field of land transportation such as the United States and Germany have established coordination mechanisms that include from the formation of working groups with representatives of different government agencies, to conducting joint pilots to test the implementation of a technology, such as hydrogen.

4.3.2. ADAPTATION MEASURES

Developing strategies to adapt road transportation to CC is a must to ensure economic growth, interurban connectivity, and access to opportunities. Extreme hydrometeorological events have historically caused significant damage to road infrastructure and operational disruptions to roads, resulting not only in significant infrastructure repair costs and economic losses due to delays, but also in isolation of rural communities and supply chain disruptions. In this context, policies to adapt road infrastructure and road transportation services to CC become especially important.

The definition of CC adaptation policies and goals specific for road transportation generally comes from the agencies in charge of road infrastructure management. Although most countries have national CC adaptation strategies in place, it is not common to find specific targets related to road transportation in these documents. However, it is possible to find adaptation objectives as part of the plans and policies developed by public agencies responsible for road management. For example, UK's National Roads Agency considers CC adaptation a priority, and its Strategic Plan 2020-2025 sets the goal of creating a CC-resilient road network (National Highways, 2020). The agency produces progress reports on this issue every five years, informing about advances on adaptation through strategies such as the development of standards and guidelines, monitoring processes, data collection, and adaptation research and pilot projects, while defining adaptation plans for the next five years (National Highways, 2022). Similarly, the US Federal Highway Administration has a policy on resilience to CC and extreme weather events (FHWA, 2014b). Under this policy, the agency must identify risks to current and future transportation systems and incorporate them into planning, operations, policies, and program processes in a manner that promotes the resilience of transportation systems.

The starting point for the adaptation of road transportation to CC is assessing the exposure and vulnerability of existing and planned transportation infrastructure and services to CC hazards. Several international methodologies have been developed to carry out risk estimation for road infrastructure projects, which generally include an identification of climate hazards and projections to be used, followed by an analysis of exposure and vulnerability of transportation systems to current and future hazards. For example, the World Road Association developed an international methodology for road infrastructure adaptation to CC, which was published in 2015 and updated in 2019 (PIARC, 2019b), and has been systematically used by road agencies in Australia and Mexico to identify and apply international best practices (PIARC, 2019a). Similarly, the ROADAPT project, led by the Conference of European Directors of Roads (CEDR), created a series of guidelines that include methodologies for using climate projections and conducting detailed vulnerability analyses (Deltares et al., 2015). The US Federal Highway Administration also has a methodology for the development of vulnerability analysis and identification of adaptation measures (FHWA, 2017), which is used in different US states for the definition of adaptation measures in road projects.

To quantify the risk and prioritize adaptation interventions in road transportation, it is vital to understand the criticality of transportation infrastructure and services. Given that road agencies usually have limited resources to implement adaptation measures, the identification of CC risks should include an analysis to identify which sections of the road network are critical to ensure access to services and the supply of goods. In this way, it will be possible to prioritize interventions in the most vulnerable and critical road sections. In line with this need, the US Federal Highway Administration has a criticality assessment methodology as part of the CC adaptation strategy (FHWA, 2014a). Another relevant example is the Blue Spot methodology –developed by the Danish Road Directorate (DRD, 2010) and also applied in the Dominican Republic (Olaya González et al., 2022)-, which allows (i) modeling the vulnerability and criticality of infrastructure at the provincial level in the face of specific climate scenarios; (ii) estimating expected annual damages and losses; (iii) proposing and prioritizing mitigation measures in the design of works (roads, bridges, ports and airports); and (iv) directing public investment towards more cost-effective interventions that strengthen the climate resilience of the national road network, emphasizing the role of resilience as a planning criterion for the government.

The identification of appropriate adaptation measures to minimize previously identified risks requires a detailed expert analysis of local conditions. The standardized risk assessment methodologies described above involve a preliminary analysis, usually based on general climate models, to identify network segments that require further attention. While this initial risk identification is very valuable for sizing the problem and justifying the need to invest in adaptation measures, defining the most appropriate adaptation measure in each specific case and making recommendations at the project level requires the use of more detailed climate and context information, as well as intervention by experts (IDB, 2019). For example, the Dominican Republic conducted a study to include CC in the prioritization of investments on the road network

Understanding local conditions is critical to identifying effective adaptation measures.

(Deltares, 2020; Olaya González et al., 2022), which required analyzing data from available local meteorological stations to identify the climate models that best represent the dynamics of historical precipitation in the different regions of the country. The projections of these models were used to update the Intensity-Duration-Frequency (IDF) curves and the return periods of the river flooding hazard. The study used the updated hazards to estimate expected annual damage and loss values, and make recommendations on possible adaptation measures to be implemented.

When incorporating adaptation strategies into the planning processes of road infrastructure agencies, coordination with mitigation strategies is essential. Given the share of road transportation in the sector's emissions, and the economic and social importance of this mode, it is crucial to align emission reduction efforts with efforts aimed at increasing the resilience of road infrastructure and transportation services to CC. A relevant intersection between adaptation and mitigation of CC for road transportation is related with the objective of minimizing energy consumption and emissions associated with the construction, operation, maintenance and decommissioning of road infrastructure. As adaptation measures may involve the implementation of construction projects, it is important to make sure that the planning stages of these projects not only consider adaptation objectives, but also seek to minimize energy consumption and associated emissions (see section 4.3.1).

In terms of regulations, the design, construction, and maintenance standards need to be updated to consider the potential effects of CC. Some advances in this area include the case of the UK's National Roads Agency, which updated the roads and bridges design manual to include climate risk and resilience standards. Additionally, it published the LA114 Standard, defining the methodology to be applied in the environmental assessment of road projects and including the requirement to identify how the project can be adapted to protect it from future climate scenarios (National Highways, 2022). Similarly, Canada has updated its bridge design code, making changes to temperature, precipitation, ice, and snow factors in accordance with the predicted effects of CC (PIARC, 2022). In Korea, the design standards for new bridges were updated to consider higher intensity extreme events, moving from designing for a 100-year return period event to a more extreme 200-year return period event (Filosa & Oster, 2015). In Denmark, road drainage standards were updated to consider CC effects (Filosa & Oster, 2015). In Norway, the public road administration updated design and construction manuals for roads and bridges to account for changes in flooding, landslides, and extreme precipitation, among others (Climate-Adapt, 2023). Additionally, under the planning and building code, risk and vulnerability analyses are a mandatory component in the infrastructure planning stage (Petkovic et al., 2019). In the United States, the Federal Highway Administration updated the manual for coastal road infrastructure subject to extreme events, to account for the fact that projected sea level rises will increase the vulnerability of a large number of coastal bridges. The changes include a new method of estimating wave loading on bridges, as well as the inclusion of adaptation strategies (PIARC, 2022).

Regulatory changes should also include considerations regarding emergency response. Traditional regulations for public works' financing, contracting, and execution can sometimes become an impediment to guarantee a timely response to CC-induced disasters, as they have very strict protocols that may not allow the mobilization of the necessary resources to rebuild infrastructure after a natural disaster. In order to minimize the impacts of extreme events and boost the system's resilience, governments might need to make these regulations more flexible or have contracts for emergency response. An example of this was evidenced in the aftermath of Hurricane Sandy in the United States in 2013, when tax regulations had to be relaxed in order to coordinate funding and efforts at the federal, state, and local levels to rebuild infrastructure (OECD, 2014).

Adaptation to CC must be included in road transportation contracts, so that adaptation plans and strategies can become a reality. The inclusion of adaptation in public procurement covers several areas. First, new road infrastructure projects present an opportunity to demand a risk analysis, compliance with updated design and construction standards, and implementation of required adaptation measures. For example, the New Zealand Transport Agency incorporated sea level rise projections recommended by the Ministry of Environment as part of the project to improve the SH16 Highway, which was elevated to withstand river flooding (PIARC, 2015). Second, maintenance contracts should be updated to increase the periodicity of maintenance activities and provide for timely emergency response. For example, in Norway, road infrastructure maintenance and operation contracts were updated to include more frequent inspections of drainage structures, require

Adaptation measures should be included from the project structuring phase.

preventive maintenance when extreme weather conditions are forecasted, and report the occurrence of extreme weather conditions (Petkovic et al., 2019). Finland updated the selection criteria for the bidding processes of road operation and maintenance contracts, adding specific participant performance factors that include their reaction time and ability during extreme weather conditions (UNECE, 2020). Third, opportunities to evaluate new materials and technologies for CC adaptation can be generated by incorporating pilots within larger contracts.

Allocation of specific funds for adaptation is an essential mechanism to boost road infrastructure resilience. It is necessary to invest in data collection to adequately assess risk, including: a complete and updated inventory of the road network and its condition; baseline hazard information and historical climate data; a record of historical impacts to the network from climate events; and future climate projections that are adequate for the local context. Once risks have been identified, it will be necessary to invest in specific adaptation measures to increase the resilience of existing infrastructure. Finally, there are also contracting needs associated with infrastructure monitoring and emergency response. In Canada, projects worth CA$2.6 million have been approved as part of the TARA initiative to carry out CC risk estimation on federal transportation infrastructure assets (Transport Canada, 2021). In Norway, EUR 2.2 million were allocated between 2012 and 2017 to the Climate and Transport program, to investigate CC impacts on the road network and recommend adaptation actions at the planning, design, construction, and maintenance stages (Petkovic et al., 2019). In the United States, state, regional, and local transportation agencies can use resources from the Federal-Aid Highway Program and Federal Lands Highway Program to invest in road transportation adaptation to CC (FHWA, 2012). The US Federal Highway Administration has funded 24 pilot studies to conduct vulnerability assessments on highway infrastructure projects across the country (FHWA & Rijkswaterstaat, 2016).

The private sector plays a key role in risk management and implementation of adaptation measures. Given the growing involvement of the private sector in financing road infrastructure projects around the world, private investors have increasingly become key players in improving the sector's resilience to CC. Investors seek to understand and minimize the risk associated with CC within their investment portfolios, which generates an incentive to require construction companies to disclose information on possible negative impacts of CC on infrastructure projects. Thus, large construction firms worldwide have begun to make progress in CC risk management, with actions such as the adoption of recommendations generated by the Task Force on Climate-related Financial Disclosures (TCFD). These recommendations seek to promote and standardize the disclosure of information on the financial risks arising from CC, so that investors, lenders, and insurers can have complete and transparent information for decision making. To the extent that investors, lenders, and insurers have better information on the risks that CC imposes on transportation infrastructure and services, it will be more likely that adaptation measures will be developed and implemented to minimize these risks.

Road transportation adaptation to CC requires investments in infrastructure and in operations and services. On the infrastructure side, the aim is to minimize impacts from potential changes in three main variables: extreme temperatures, extreme precipitation, and sea level rise. Structural adaptation measures recommended in the literature to reduce the impacts derived from these variables include changes in pavement materials to make them more resistant to extreme temperatures; increasing the capacity of drainage structures; reinforcing bridge piers and abutments; stabilizing slopes to prevent landslides due to soil saturation; constructing barriers to prevent coastal flooding and infrastructure erosion; elevating infrastructure to minimize flood risks; relocating infrastructure to lower-risk areas; and constructing additional roads to increase redundancy. In addition, there are NBSs that allow road infrastructure to be adapted to CC, with usually lower costs than alternatives requiring infrastructure works. Some NBS examples include the use of vegetation alongside roads to provide shade and reduce temperatures, or the use of permeable pavements that allow water to seep into the ground and reduce the load on drainage systems. The US Federal Highway Administration has a guide for NBS implementation on coastal roads that recommends using natural defenses such as dunes, mangroves, beaches, wetlands, and vegetation, which are restored or reinforced to be employed in replacement of or in combination with other structural barriers to prevent coastal flooding (FHWA, 2019). On the operations and services side, the main investments are associated with increasing the frequency of preventive maintenance, implementing

Private investors are boosting CC adaptation in road projects.

early warning systems, improving traveler information systems, and executing emergency response plans.

Table 4.2 shows the measures that are most commonly used by benchmark countries in the sector, against which to compare the state of this issue in LAC.

TABLE 4.2. **Road transportation policies implemented at international level***

Levels	Mitigation	Adaptation
Plans / strategies	• Setting emission reduction targets in the road subsector at the national and local levels	• Adaptation plans at the national level that refer to the road subsector • Adaptation objectives in plans and policies developed by road infrastructure agencies • Exposure, vulnerability, and criticality estimates for road transportation infrastructure and services • Prioritization of interventions on existing and planned road networks based on risk estimates • Coordination of adaptation measures with mitigation targets
Regulations	• Regulation on fuel quality (promotion of low-carbon fuels) • Zero-emission vehicles • Emission standards by vehicle type • Regulation on road infrastructure charging: differentiation by CO2 emissions, consideration of externalities associated with pollution, consideration of congestion charges, use of revenues collected, etc.	• Updating road design and construction standards • Ban on road and bridge construction in high-risk areas • Legislation related to emergency response
Public procurement	• Setting emission reduction targets • Bonus and penalty systems	• Vulnerability and risk analysis in design contracts • Adaptation measures in construction contracts • Increased recurrence in infrastructure maintenance contracts • Distribution of risks between the public and private sectors in the face of extreme weather conditions • Performance-based contracts that include resilience objectives and indicators • Incorporation of pilots for the evaluation of new materials and technologies for CC adaptation as part of new contracts

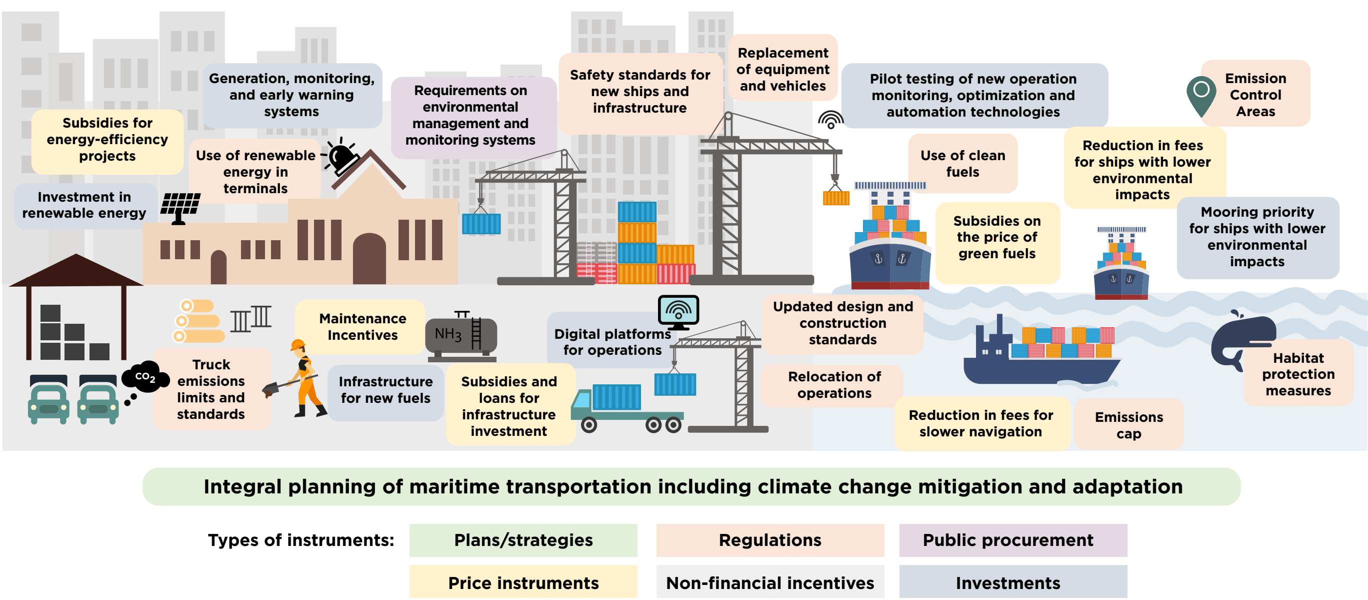
Levels		Mitigation	Adaptation
Pricing instruments		**ENERGY** • Prices for GHG emissions • Fuel tax • Emissions trading scheme for road transportation **VEHICLES** • Tax on vehicles (differentiated by CO2) • Incentives for the purchase of electric vehicles **INFRASTRUCTURE** • Road infrastructure pricing (smart pricing, differentiated by CO2) • Exemption from road charges for electric vehicles	• Allocation of specific funds for the adaptation of roads to CC • Requirement for adoption of recommendations on disclosure of climate-related financial risks by the private sector
Non-financial incentives		• Vehicle labeling (including fuel efficiency and CO2 emissions) • Eco-driving	• Training in adaptation to climate change and risks in road transportation infrastructure
Investments	**Infrastructure**	• Use of IT tools, such as Life Cycle Assessment software • Electric vehicles and charging infrastructure • ITS and ICT for infrastructure management, maximizing its capacity and durability	• Pavements that are more resistant to extreme temperatures • Permeable pavements • Expansion of drainage systems • Reinforcement of piles and abutments in bridges • Stabilization of slopes • Construction of barriers • Elevation of roads and bridges • Relocation of infrastructure • NBS development
	Operations and services	• ITS and ICT for fleet management and improved operational efficiency	• Increased frequency in preventive maintenance of roads, bridges, tunnels, and drainage works • Implementation of early warning systems for emergencies • Development of emergency response plans • Increased use of the traveler information system

Source: Prepared by the authors
Note: *Non-exhaustive list of policies.

4.4.
Measures for maritime transportation decarbonization and adaptation

Advancing in decarbonization and CC adaptation of maritime transportation requires a comprehensive approach, including measures in different policy areas for this subsector and in coordination with other government sectors. This subsection identifies successful measures implemented by benchmark countries in different action areas. However, these measures should not be considered in isolation, since successfully achieving decarbonization and adaptation objectives requires a combination of policy measures and a joint approach to them (Figure 4.4).

FIGURE 4.4. **Maritime transportation decarbonization and adaptation***



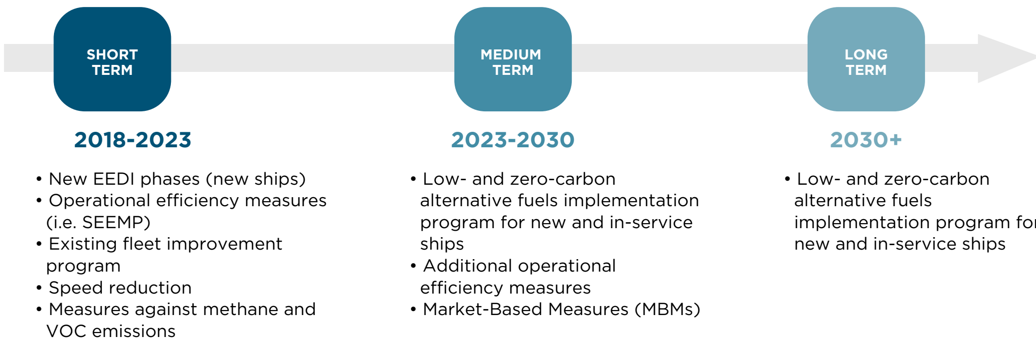
Source: Prepared by the authors
Note: * Non-exhaustive list of measures

4.4.1 MITIGATION MEASURES

Although maritime transportation makes a marginal contribution to the region's emissions, at the global level it represents nearly 3% of GHG emissions. If it were a country, this subsector would be the world's sixth largest emitter. For this reason, the IMO published in 2018 the so-called Initial Strategy to advance the subsector's decarbonization and prevent BAU scenarios from materializing, which estimate an increase between 90% and 130% of emissions by 2050, compared to 2008 levels. This strategy was revised in July 2023, establishing more ambitious goals for the subsector.

IMO's revised strategy sets the goal of achieving carbon neutrality in international shipping by 2050, taking 2008 as a baseline. To this end, it recommends increasing energy efficiency in maritime-port operations, although it is recognized that the greatest impact will come from the transition to clean or net-zero fuels. Moving maritime transportation beyond national borders, the IMO strategy aims to identify short-, medium-, and long-term measures to be implemented through collective action at the global level (Figure 4.5). One mandatory measure is a 30% reduction in the carbon intensity of new ships by 2025 and a 40% reduction in the carbon intensity of all ships by 2030, according to the Energy Efficiency Design Index (EEDI). However, for the most part, the recommendations are voluntary in nature, including the development of Action Plans at the national level that consider institutional and legislative strengthening to incentivize the energy transition, support for research on energy sources for the subsector, and facilitation of green infrastructure development. Nevertheless, new measures of a mandatory nature for industry and States are expected to emerge from the next negotiation rounds between 2024 and 2026.

FIGURE 4.5. **Measures to reduce emissions in maritime transportation**



Source: Prepared by the authors based on ICCT (2020) .

In line with IMO guidelines, countries in different latitudes have formulated or updated plans and strategies, recognizing the importance of promoting decarbonization. Some, like Germany and India, have included this issue in the update of their national maritime-port policy, highlighting the importance of migrating in the short term towards electrification of operations, based on renewable energy sources such as solar and wind, and in the long term towards hydrogen and ammonia as fuels for the subsector. Countries such as the United Kingdom and Singapore have developed specific strategies for energy transformation, identifying regulatory, infrastructure, and financial requirements for the subsector. Regardless of the type of document used, benchmark countries in maritime transportation are characterized by long-term planning, with a particular focus on transportation decarbonization.

The first step in such plans and strategies is the collection, systematization and updating of emissions data at the port level. This is key to establish a baseline of GHG emissions and identify future reduction targets. For example, the ports of Hamburg and Rotterdam aim to reduce 50% of their direct CO2 emissions by 2025. Emission inventories help identify areas where energy efficiency and progress monitoring should be promoted to obtain environmental and financial benefits. In general, it is the Port Authorities that drive and implement this action, with different geographical scopes. Some ports stay within their administrative boundaries (the Port of Rotterdam, for example), while others expand the geographical area offshore and into the hinterlands (e.g., the ports of Los Angeles and Long Beach).

Achieving GHG reduction targets requires a set of energy conservation and efficiency measures. Although maritime transportation is a much more efficient mode than road, rail or air transportation, which consumes 20% of the total energy used in transportation to move 90% of the world's freight, there is considerable room for improvement in this subsector to reduce its energy consumption. In some countries, such as Germany and India, national plans for the subsector establish general guidelines for measures to adopt, which are then developed in more detail at the port level. In other cases, the Port Authority determines the measures for terminals, carriers and shipping lines. For example, the Port Authorities of Hamburg and Singapore have established that their harbors must be carbon neutral by 2050. At the same time, as part of their corporate social responsibility programs, shipping lines, global logistics operators and terminals are also deploying their own actions to improve energy efficiency, in many cases in line with the measures set by the Port Authorities. For example, Maersk aims to achieve carbon neutrality by 2040, while Evergreen, CMA CGM and MOL are targeting 2050.

There are examples of international best practices for all five policy instruments, namely: (i) regulations limiting the emission of pollutants; (ii) procurement processes that include environmental criteria; (iii) pricing mechanisms; (iv) non-financial incentives; and (v) public sector investments. The most commonly used regulatory measures at the terminal level are setting an emissions cap, the replacement of equipment and vehicles with those that use electric power, the use of electric power by ships at berth, and the use of a percentage of renewable energy in operations. For example, by 2030 the Port of Singapore will require all vessels operating in it to use low-carbon energy. By 2050, they must be electric or use net-zero energy. For its part, the European Commission established in its 2021 Green Pact that by 2050 the region's port-cities must reduce their emissions by 90%. India's goal is that by 2030, 60% of the energy used by its ports should come from renewable sources.

Other regulations apply to terminal users, such as trucking companies. The establishment of emission standards and limits for trucks was a measure successfully implemented in ports such as Los Angeles and

The incorporation of environmental criteria in bidding processes is incipient.

Long Beach, achieving an 80% reduction in emissions from this mode. This measure has also been adopted in New York and New Jersey. In the case of Vancouver, in order to obtain a license to operate at the port, a truck must comply with environmental management program requirements, including the installation of emission reduction equipment on board such as filters and catalytic converters.

Regarding regulations for the maritime industry, the EEDI, the Ship Energy Efficiency Management Plan (SEEMP) and Emission Control Areas (ECAs) have the greatest international acceptance. The first two are required internationally to an increasing number of ships, in the context of the IMO mandate, in order to reduce energy consumption and thus the level of emissions. The third regulation has been adopted by several advanced countries with the aim of improving air quality in the port area, especially in urban contexts. For example, Korea and the Baltic countries have stipulated that ships sailing in these areas must use fuels with a sulfur level below 0.1%. A measure that is still in its infancy but will become more common in the future is the limitation of carbon content in the fuel used by ships. For example, the EU's FuelEU initiative, currently under discussion, proposes a staggered reduction, starting at 2% in 2025 and reaching 75% in 2050.

Recently, environmental requirements have begun to be incorporated into the bidding processes for port works and services. These usually refer to the use of environmental management and monitoring systems, energy performance targets, the use of renewable energy sources, and technical specifications to limit emissions. In the Maasvlakte 2 expansion in the port of Rotterdam, for example, facilitating mode shift was scored as a criterion in the call for proposals. In the case of Spain, carbon intensity is included as an evaluation criterion for towage service concessions.

Currently, there are different price-based incentives to promote energy efficiency. The most commonly used is to charge a lower port fee to ships with lower environmental impacts, estimated according to the ship's characteristics. At the International level, there are several indexes making these appraisals, such as the GHG Emissions Rating, the Environmental Ship Index (ESI), the Green Award, and the Clean Shipping Index. For example, the port of Hamburg grants discounts of up to EUR 3,000 in port fees for ships with the best ESI score. In the region, the Port of Buenos Aires provides discounts of up to 10% on port fees for the least polluting ships. In places such as Los Angeles and Long Beach, slower shipping is also rewarded with lower rates. Another widely used instrument is subsidizing energy efficiency projects in port assets and operations, either via tax exemption or non-refundable contributions. Through its Bipartisan Infrastructure Act of 2021, the United States granted funds exceeding USD 150 million for the electrification of port equipment and USD 100 million for projects aimed at the deployment of offshore solar infrastructure.

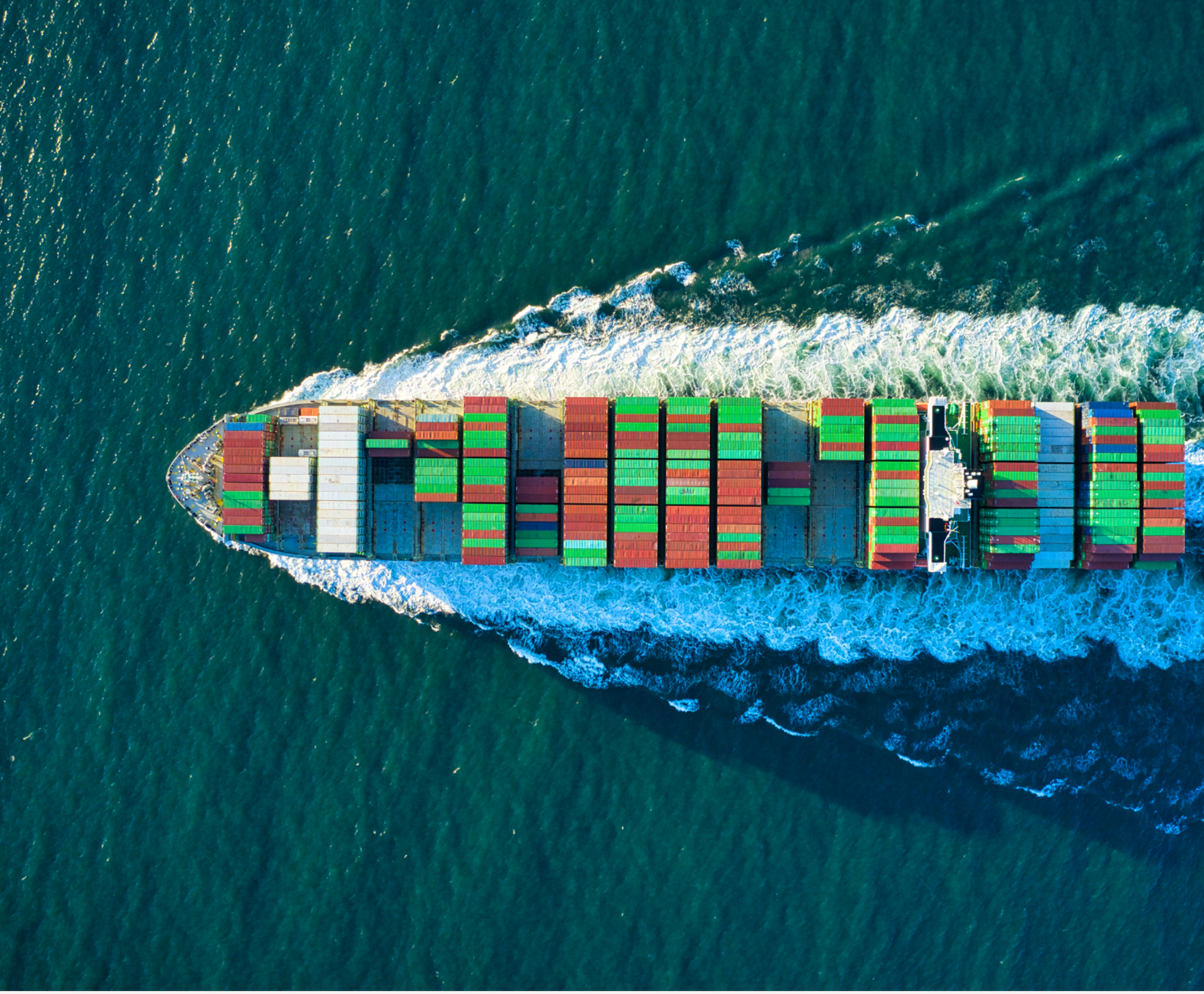
One of the measures with the greatest potential in this group is carbon pricing. The expectation is that establishing a price per unit of carbon or GHG emissions will help internalize the negative effect of maritime transportation on the environment, while at the same time encourage innovation and energy transition of the subsector towards sustainable energy sources. So far, the greatest progress has been made in the area of carbon trading. Singapore and China already have schemes through which shipping companies can offset their emissions by acquiring credits via investments in green projects. For example, the Climate Impact X marketplace in Singapore allows financing of projects ranging from mangrove restoration to improving CC resilience in coastal areas. Some countries –e.g. Sweden– apply carbon taxes to inland shipping. However, the global nature of shipping makes it difficult to implement a carbon pricing scheme at the national level. For this reason, the establishment of an international scheme is being contemplated among the medium-term measures for GHG reduction in the IMO strategy. In this area, in 2023 the maritime sector will become part of the EU ETS, whereby cargo and passenger ships over 5,000 gross tonnes will have to acquire CO2 emission permits.

Non-financial incentives are varied and target different port operations actors. Some terminals or Authorities, such as the Panama Canal, give mooring or passage priority to ships with better emission ratings. Others have facilitated the implementation of pilots with new technologies for real-time monitoring of emissions, optimization of operations with AI, and automation of equipment, among others, in order to reduce energy consumption. There are numerous examples of this around the world, such as those implemented by the ports of Singapore, Rotterdam, Hamburg, and Shanghai.

The public sector also makes investments that improve energy efficiency in shipping. These can be aimed at providing renewable energy for port operations, as in the cases of Australia and the United States for offshore wind energy production. They may also aim to develop digital platforms that simplify processes, generate and centralize information and enable better planning and synchronization of operations –including those on the "water side"– with a consequent reduction in energy consumption. In this regard, there are numerous cases worldwide of implementation of maritime single windows and Port Community Systems (see Calatayud et al., 2022). In the region, between 2007 and 2012, the port of Valparaíso reduced CO2 emissions from cargo handling activities by 84% with the implementation of a management and information exchange system to better synchronize the processes of shipping lines, terminals, and carriers (Port of Valparaíso, 2014).

While energy efficiency is an important step to reduce shipping emissions, meeting international targets will require migrating to zero or net-zero (or "clean") emission fuels. Recent estimates suggest that logistics optimization and redesign of vessels and navigation systems could reduce emissions intensity by up to 55%, with a significant gap to be filled via new fuels. This also requires the development of new engines and a new generation of ships, as well as the modernization of port and energy infrastructure. In this regard, the Global Maritime Forum estimates that the investments needed to achieve the IMO goals by 2050 are around USD 1 trillion, of which 90% would be allocated to energy production, storage and transmission infrastructure, and the remainder to the shipping industry. In comparison, global energy investments in 2022 were USD 2.5 trillion (IEA, 2023b). Given the magnitude of this challenge, the present decade is referred to as the "decade of action" to indicate that the time to generate incentives and align targets to drive the transition is now. Indeed, to be consistent with the emissions trajectory stipulated in the IMO strategy, 5% of the fuel used in the subsector must be clean by 2030.

As in the case of energy efficiency, benchmark countries have established public policy mechanisms to stimulate the transition. In these cases, maritime-port plans and strategies already include decarbonization as a major subsector goal, also identifying the types of fuels to generate the transition. Hydrogen and ammonia are prioritized in this regard, especially the so-called "green" ones (Figure 4.6). This

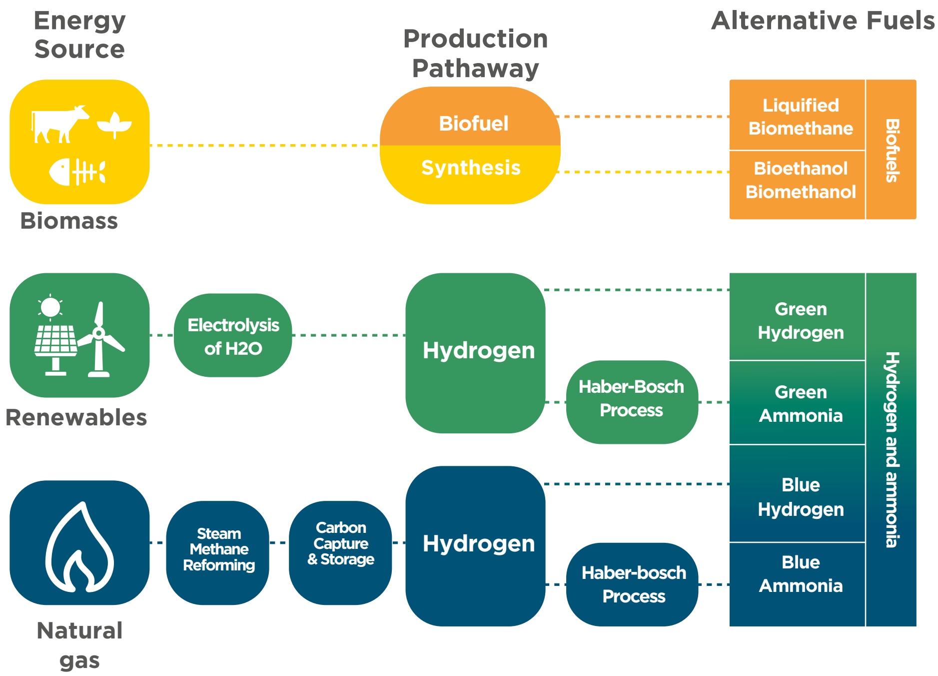


Logistics optimization and redesign of vessels and navigation systems could reduce emissions intensity by up to 55%, with a significant gap still to be filled via new fuels.

By 2030, 5% of the fuel used in the subsector must be clean.

is the case in the United Kingdom, Japan, India, Germany and Korea, to name a few. There are also roadmaps for hydrogen development that identify shipping as a major user of hydrogen, especially in cases where the maritime industry is an important factor in the national economy, as in Singapore. Denmark has even developed a hydrogen roadmap specifically for shipping, setting out guidelines for policy and regulation, infrastructure, technology, and safety.

FIGURE 4.6. **Alternative fuels and their production**



Source: Global Maritime Forum (2022).

Regulations have the dual purpose of driving the energy transition and ensuring safety. As in the case of energy efficiency, it will be increasingly common to find regulations mandating the use of clean fuels in a percentage of movements or types of vessels. Singapore's strategy already indicates that by 2050 all port service vessels will have to use a combination of electric power and zero-net fuel sources for their operation. On the other hand, the development of new ships and infrastructure, as well as the management of new energy sources, will require issuing safety standards for their production, management and disposal. In particular, ammonia is highly harmful to health, flammable and corrosive, and therefore poses significant risks to the marine environment and persons. In any case, regulation must give room for innovation, for which regulatory sandboxes that have been successfully tested in other areas of transportation, such as the testing of autonomous vehicles and the deployment of drones, are useful. These could be applied to the deployment of ships with new fuels and the development of green corridors, which is currently being studied in Singapore.

The role of pricing instruments will be key to reduce the cost of fuel as technology development advances and production scales. Recent studies estimate the cost of green hydrogen at an equivalent of between USD 250 and USD 450 per barrel of crude oil ex-works, while the price of a barrel of crude oil is in the USD 100s (IRENA, 2020). Although we are still at an early stage of the transition, there are already guidelines on what financial incentives could be useful to promote it. These include exemption from port charges for ships using green fuels; R&D incentives; subsidies and/or loans at subsidized rates for the CAPEX of green fuel generation, transmission and storage infrastructure; subsidies for the purchase of this fuel; among others. Finally, CO2 emission charges to ports, shipping lines and freight providers are identified as one of the main mechanisms to close the cost gap with green fuels. The strategies of the United Kingdom, Korea and Japan, for example, already include a battery of instruments to promote testing and development of these fuels.

Capacity building and alliances between academia, industry and the public sector are currently the most widely used non-financial instruments. There are important global initiatives such as the Global Maritime Forum's Getting to Zero Coalition and the Zero-Emission Shipping Mission, which bring together port authorities and terminals, shipping companies, freight providers and universities to generate global and regional consensus on decarbonization of the subsector. At the national level, the decarbonization strategies of the United Kingdom and Singapore place great emphasis and allocate resources for research projects and training on the skills required for the transition, which are provided by their universities. On the other hand, due to the incipient state of technological development, public procurement does not yet play a relevant role as an instrument to promote the transition.

Green corridors are one of the mechanisms encouraged at the international level by the IMO. These refer to specific maritime routes between two or more ports, in which energy with zero net emissions is used. Having this space secured generates certainty for the private sector to make the investments required by new energy sources. It can also be used as a testing ground for the technology and regulations needed to scale it up, while focusing incentives for innovation to reduce the cost of private investment. Although no initiatives are being implemented yet, those developed in the future should not only involve ports and shipping companies, but also freight providers willing to pay an additional cost, motivated by reducing emissions in their supply chains. Through the instruments mentioned above, public policy can contribute to the promotion of these corridors, either by reducing the cost of fuel and/or by generating the appropriate ecosystem for their promotion, starting with preliminary analyses for the deployment of the corridors. For example, the UK government has funded feasibility studies for three corridors, while the Nordic Council of Ministers has earmarked resources to study routes in northern Europe.

4.4.2. ADAPTATION MEASURES

In addition to GHG mitigation measures, CC adaptation is beginning to be incorporated into subsector policies and plans. As seen above, rising sea levels and the frequency of extreme weather events threaten to have devastating effects on ports, so methodologies, guidelines and standards are being developed internationally to identify risks as well as their potential impact and mitigation measures. Entities such as the World Association for Waterborne Transport Infrastructure (PIANC), the International Standards Organization, and the European Commission have made available different instruments to assist countries in this endeavor.

International best practices show that, in the first place, national plans and strategies should recognize that adaptation to CC is crucial for the future of the subsector. This can be evidenced in crosscutting CC plans at the national and/or regional levels, where port and coastal infrastructure is explicitly mentioned, as is the case in Singapore and Jamaica, and in Colombia's Atlantic region. Elsewhere, for example in Canada and the United Kingdom, it is mentioned within the specific plans for the maritime subsector. Lastly, a large number of Port Authorities at the international forefront such as Rotterdam, Barcelona and Valencia have produced adaptation plans according to their respective degrees of exposure. The common denominators of these experiences are the identification of CC adaptation as one of the strategic goals at national and local level, giving top priority to the issue, and making it a starting point for the development of specific actions.

Specific adaptation plans for the subsector or for a given infrastructure include both soft and hard measures. The former refer to regulations, institutional arrangements and instruments that can be used by public policy to promote adaptation, as will be discussed below. The latter involve structural changes for ports, categorized into three groups: elevate, defend and withdraw (Van Houtven et al., 2022). Elevate refers to raising the port surface and related infrastructure using fill material and reconstructing buildings to a higher elevation. It includes raising piers, yards, tracks, warehouses, and bridges if necessary to reduce vulnerability to sea level rise. Defend involves constructing or modifying levees, seawalls, floodgates, drainage systems, and using NBSs, among other actions, to reduce vulnerability to storms, storm surge and sea level rise. Retreat refers to relocating the port or part of its infrastructure to areas of lower risk. In general, most actions are focused on defending. For example, the ports of Long Beach and Baltimore have installed concrete walls to prevent flooding. The ports of Civitavecchia in Italy, Zeebrugge in Belgium and Gijón in Spain have resorted to the use of seawalls with breakwaters, while those of Algeciras, Barcelona and Bilbao have reinforced their breakwaters to adapt to stronger storms and higher waves. NBSs are also used, as in the cases of the port of Miami, which has restored 16 hectares of mangroves, or the ports of San Diego and Portland, where rain gardens and vegetated channels have been installed to reduce their exposure to flooding.

First and foremost, the planning exercise must be based on a robust analysis of the risks generated by CC. This analysis can be carried out at different levels: national or regional, to have an overview of the hazards for the sector and feed into sectoral planning and strategies; and

The potential of pricing instruments to incentivize CC adaptation has been little explored.

local, at the level of the specific infrastructure, to identify hazards and vulnerabilities and define concrete adaptation measures. The analysis should include assessments of: (i) climate hazards according to the potential evolution of climate factors; (ii) exposure of infrastructure and its operations to such hazards; and (iii) their vulnerability to damage and losses (UNCTAD, 2020). This requires historical and prospective information on the evolution of climate variables, the characteristics of infrastructure, and the evolution of supply and demand, as well as the technical and technological capacity to manage information and estimate potential changes. At the international level, most analyses focus on a specific port, which makes it possible to increase the robustness of the scenarios and estimate CC hazards with greater precision. An interesting exercise is that of Colombia, which developed a general CC plan for its ports that presents a guide for identifying CC adaptation measures based on individual vulnerability scenarios.

The regulatory framework plays an important role in encouraging the inclusion of adaptation measures in the planning and design of maritime-port infrastructure. An increasingly used measure in this regard is to modify design and construction standards to incorporate CC into environmental impact analyses and to develop mitigation and adaptation plans for the infrastructure under consideration. This is the case in California for state infrastructure projects and in European countries, where the EU issued a directive for this purpose back in 2014. Other measures include: development of contingency plans; availability of monitoring and early warning systems; inspection of infrastructure; prioritization of redundancy to ensure continuity in the face of shocks; relocation of operations out of higher risk zones and limiting new developments in such zones; changes in zoning according to risk assessment; habitat protection measures to reduce risks to infrastructure and operation; and more robust resilience requirements in the case of reconstruction (PIANC, 2023). Given that in most cases ports are operated by concessionaires, these requirements can be incorporated into bidding processes and concession contracts to ensure their prioritization and compliance.

Pricing instruments have not been widely used, but have great potential. Charging for non-compliance with resilience and adaptation regulations and standards, reducing costs of insurance for infrastructure that incorporates such standards, creating a contingency fund to respond to natural disasters, and providing incentives for maintenance (for example, within concession contracts) are some of the instruments being considered by the most advanced countries in this area.

The most common non-financial incentives are knowledge exchange, promotion of research, and awareness and training programs. These are widespread and supported by programs of international organizations such as IMO, UNCTAD and the EU, as well as by bilateral cooperation between governments.

Maritime transportation is fundamentally a private business, so collaboration between companies and the public sector is key to promote decarbonization and adaptation. From the experience of benchmark countries, three main coordination mechanisms can be observed: (i) institutional coordination; (ii) coordination for technological development; and (iii) consultation with the private sector as part of the development of strategic plans for the sector. In the first case, ad hoc or permanent working groups are established, for example, in the context of the Port Community Systems, where sustainability is included among the coordination topics. Antwerp, Rotterdam and Hamburg are examples of this practice. In the second case, specific projects are developed with the industry, where the public sector uses financial and non-financial instruments to support such developments. Experiences are numerous around the world, especially in piloting new technological and energy transition solutions. In the third case, industry is involved at an early stage of planning, to receive its input and subsequently validate the contents of the plan. This coordination is critical, given that many private actors already have their own studies and strategies –for example, those related to Green Ports[19]– that can contribute to achieving the public objectives. In the region, the CC management plan for Colombia's ports included input from the adaptation study developed by the Port Society of Cartagena to identify management strategies for that coastal zone.

[19] Green Port strategies, adopted by port operators and authorities in different latitudes, aim to develop port operations in environmentally friendly environments, reducing polluting emissions and waste, and mitigating their impact on air quality and the marine environment. Thus, the decarbonization of maritime transportation is part of the broader Green Port strategy.

This coordination is essential in the context of port-cities, both to achieve climate goals and to improve living conditions in these areas. Along these lines, Rotterdam's local government developed the Rotterdam Climate Agreement in 2019 in consultation with more than 100 companies and civil society organizations, including the maritime-port sector. The deal contains 49 actions to reduce 49% of the city's CO2 emissions by 2030 (based on 2017). It is organized in five areas, one of which concerns port activity (Cities of Tomorrow, 2020). There are also initiatives originating at the port level and involving local institutions and stakeholders. For example, the ports of Long Beach and Los Angeles jointly developed the Clean Air Action Plan, conducting numerous workshops to gather input and validate the plan with a wide variety of stakeholders (Clean Air Action Plan, 2017), from area residents to ground transportation companies and environmental institutions. From this plan emerged the Clean Truck Program, whose benefits were illustrated in the preceding paragraphs.

By way of summary, Table 4.3 includes the most widely used measures by benchmark countries worldwide, against which to compare the state of this issue in LAC.

TABLE 4.3. Maritime transportation policies implemented at international level*

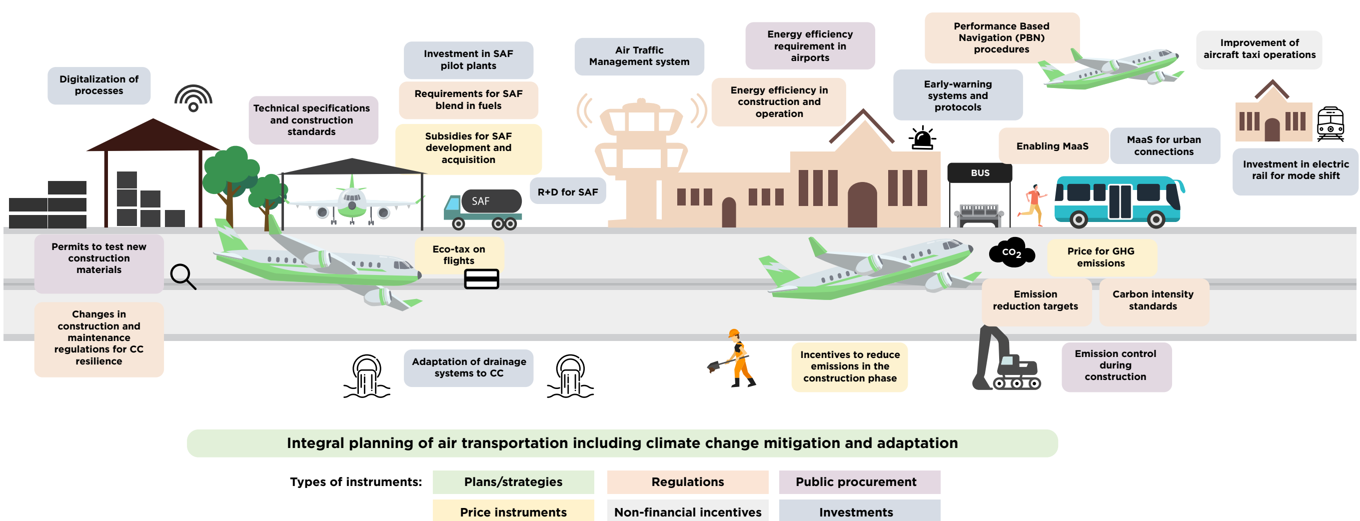
Levels	Mitigation		Adaptation
	Energy efficiency	Energy transition	
Regulations	• Setting emission caps • Replacement of equipment and vehicles • Emission standards and limits for trucks • Adoption of EEDI and SEEMP • Emission Control Areas (ECAs)	• Setting emission caps • Replacement of equipment and vehicles • Use of renewable energy at terminals • Use of clean fuels • Safety standards for new vessels and infrastructure • Regulatory sandboxes	• Modification of design and construction standards • Requirement for infrastructure mitigation and adaptation plans • Changes in infrastructure inspection requirements • Zoning changes • Relocation of operations • Habitat protection measures
Public procurement	• Requirements of environmental management and monitoring systems, energy performance objectives, use of renewable energy sources and technical specifications to limit emissions in bidding processes for works and services	N/A	• Requirements in concession contracts for the preparation of contingency plans, availability of monitoring and early warning systems, and redundancy to avoid disruptions, among others
Pricing instruments	• Reduction of fees for ships with lower environmental impacts • Reduction of fees for slow navigation • Subsidies for energy efficiency projects • Carbon pricing	• Exemption from fees for clean ships • R+D stimulus for technological and energy development • Subsidies and loans for infrastructure investment • Green fuel price subsidy • Incentives for green corridors and clean energy hubs	• Penalty for not complying with regulations and standards of resilience and adaptation • Reduction of insurance costs for infrastructure that meets resilience and adaptation standards • Contingency fund for natural disasters • Maintenance incentives
Non-financial incentives	• Mooring or passage priority for vessels with lower environmental impacts • Pilots with new technologies for monitoring, optimization and automation of operations	• International alliances to share best practices and build consensus • Research and academic and labor market training • Studies for green corridors and clean energy hubs	• International alliances to share best practices and build consensus • Research, academic training, and market labor training • Studies for green corridors and clean energy hubs
Investments	• Investment in renewable energy • Digital platforms for simplification and integration of operations	• Investment in development and infrastructure for new fuels	• Generation, monitoring, andearly warning systems

Source: Prepared by the authors.
Note: *Non-exhaustive list of policies.

4.5.
Measures for air transportation decarbonization and adaptation

Advancing decarbonization and adaptation to CC in air transportation requires a comprehensive approach, including measures in different policy areas for this subsector and in coordination with other government sectors. This subsection identifies successful measures implemented by benchmark countries in different action areas. However, these measures should not be considered in isolation; rather, successfully achieving decarbonization and adaptation goals requires a combination of policy measures and a joint approach to them (Figure 4.7.).

FIGURE 4.7. **Air transportation decarbonization and adaptation***



Source: Prepared by the authors
Note: * Non-exhaustive list of measures

4.5.1 MITIGATION MEASURES

Although air transportation accounts for less than 3% of global CO2 emissions (IEA, 2022g), these are expected to triple by 2050 compared to 2018 (ICAO & Fleming, 2022). To reverse this trend, ICAO established in 2010 a global aspirational target that aims to improve fuel efficiency by 2% per year until 2050 and maintain net emission levels at the 2020 value. In 2022, recognizing the challenge of meeting Paris Agreement targets, it proposed a long-term global aspirational goal of zero net carbon emissions by 2050 to its member countries. To this end, ICAO recommends adopting a set of mutually complementary measures, which can be classified into four areas: (i) technological improvements in aircrafts; (ii) improvements in air and ground operations; (iii) large-scale adoption of Sustainable Aviation Fuels (SAF); and (iv) measures based on carbon markets (structured under the CORSIA program). ICAO's 193 member countries have committed efforts to adopt this "basket of measures," which have been formalized through a series of resolutions on environmental protection approved in 2022.

Technological improvement of aircrafts is making progress with greater engine efficiency, modifications in wing design, and the use of lighter materials, among other strategies. The latest aircraft generation, including the Airbus Neo and Boeing Max versions, offer efficiency improvements of up to 20% compared to the previous versions, which were developed some 10 years ago. Zero-emission aircrafts powered by green hydrogen or electricity are also being tested to get a commercial version by 2035. However, the penetration of the latest aircraft generation in the industry is still low, which foretells an inertial continuity in the improvement of average efficiency until the end of this decade, as new technologies mature and airlines replace their fleets with new models.

ICAO has designed a path to improve air and ground operations. In its Global Air Navigation Plan, ICAO presents a gradual aviation system improvement methodology (Basic Building Blocks framework), which provides a programmatic and flexible approach for each Member State to advance its air navigation capabilities according to its specific operational requirements (ICAO, 2016). The improvement blocks enable global harmonization to be achieved, capacity to be increased, and environmental efficiency to be improved for air traffic growth. These include air traffic management measures, route optimization, efficient use of airspace, improved aircraft taxi operations and energy efficiency at airports, and performance-based navigation procedures. The latter is crucial, since inefficiencies in horizontal and vertical flight movements account for 6% to 7% of total fuel burned (ICAO, 2022c).

ICAO has also developed a policy framework to incentivize sustainable aviation fuels (SAFs). As will be discussed below, SAFs have significant potential for reducing net lifecycle GHG emissions from international aviation, as well as emissions of conventional air quality pollutants (ICAO, 2022b). The industry points to SAF as the only feasible pathway to achieving the net-zero goal by 2050. ICAO-driven SAF promotion actions are grouped along three axes: (i) stimulating SAF production growth through research and investment; (ii) increasing SAF demand through subsidies and formal commitments; and (iii) enabling the SAF market through standards and accreditation of SAF environmental attributes (ICAO, 2022b).

The CORSIA program complements the above measures by regulating the compensation of CO_2 emissions that cannot be reduced via technological, operational or energy source improvements. CORSIA offers a harmonized way to reduce emissions from international aviation, minimizing market distortions while respecting the special circumstances and respective capabilities of ICAO member states. Established in 2016, the program is implemented in three phases: a pilot phase (2021-2023), a first phase (2024-2026), and a second phase (2027-2035). Participation is voluntary until 2026, and starting on 2027 participation will be determined using 2018 ton-km baseline information. As of January 1st of 2023, 115 states had announced their intention to participate in CORSIA. As an international program, CORSIA establishes harmonized standards for the certification of SAF and emission offsets. CORSIA involves the attribution of international flights to operators and from these to States, as well as the definition of record keeping requirements, compliance periods, and deadlines. It also establishes the requirements and methodology to be used in the monitoring, reporting, and annual verification of CO_2 emissions.

Carbon markets are gaining prominence as an emissions mitigation measure. These can be implemented through carbon taxation (which puts a price on GHG emissions) or Emissions Trading Systems (which value carbon indirectly, by setting an overall emissions target for a given

The development of SAF is the sector's major commitment to achieve the goal of zero-net emissions by 2050.

The benchmark countries have strategies that prioritize decarbonization.

period and allowing trading of emissions) (ITF, 2021). At the international level, the most developed system is the EU ETS, in force since 2012: a mechanism applied to all companies flying in the European space that sets an annual emissions reduction target as well as tradable emissions allowances. This system has contributed to reducing the aviation sector's carbon footprint by more than 17 $MtCO_2$ per year (European Commission Climate Action, 2023).

A large number of countries have aligned their air transportation plans and strategies with ICAO's decarbonization guidelines. France, for example, establishes as the first axis of its National Air Transport Strategy 2025 to ensure the sector's ecological transition and sustainability, echoing the basket of measures suggested by ICAO. In LAC, Colombia's Aeronautical Strategic Plan 2030 envisages improving the resilience and flexibility of air operations to the effects of CC, as well as the development of a dedicated environmental policy and a mechanism to guide aeronautical and airport infrastructure in mitigating environmental impact. For its part, the United Kingdom has developed a specific strategy for decarbonization, called Jet-Zero Strategy, which defines medium- and long-term mitigation goals, such as achieving a net-zero domestic flight policy by 2040 and mandatory use of SAF at 10% by 2030. ICAO also provides support for the development of national action plans for the reduction of GHG emissions, with a battery of technical assistance tools and the possibility of submitting documents to ICAO for their review. These action plans seek to implement the basket of measures identified by ICAO. For example, Chile's Action Plan mentions, among other measures, the implementation of an emissions monitoring system for international flights of Chilean air operators as part of the CORSIA program. This is also the case of Brazil's Action Plan, which refers to market-based measures as mitigation mechanisms, through both the CORSIA program and the implementation of the national biofuels program RenovaBio using the Biofuels Decarbonization Credit.

The initiative with the greatest single impact in the short to medium term is the promotion of energy transformation in aviation using SAF. SAF is a "drop-in" fuel, which can be blended with traditional jet fuel for use in existing aircraft and handled by existing airport fuel infrastructure without any reforms. Compared to traditional jet fuel, SAF offers up to 100% net carbon emission reductions over its life cycle, depending on inputs and manufacturing routes. Currently, manufacturing routes certified by the

ASTM organization allow up to 50% SAF in the jet fuel blend. Current and potential SAF inputs include: (i) cooking oils, vegetable oils and animal fats (HEFA manufacturing route); (ii) corn or sugarcane ethanol (Alcohol-to- jet); (iii) agricultural, forestry and municipal solid wastes (Gasification/ FT); and (iv) green hydrogen (Power-to-liquid - PtL) (Figure 4.8).

FIGURE 4.8. **SAF Inputs**

	HEFA	Alcohol-to-jet[1] / Gasification / FT	Power-to-liquid
Opportunity description	Safe, proven, and scalable technology	Potential in the mid-term, however significant techno-economic uncertainty	Proof of concept 2025+ primarily where cheap high-volume electricity is avallable
Technology maturity	Mature	Commercial pilot	In development
Feedstock	Waste and residue lipids, purposely grown oil energy plants[2] Transportable and with existing supply chains Potential to cover 5%-10% of total jet fuel demand	Agricultural and forestry residues, municipal solid waste[4], purposely grown cellulosic energy crops[5] High avallabillity of cheap feedstock, but fragmented collection	CO_2 and green electricity Unlimited potential via direct air capture Point source capture as bridging technology
% LCA GHG reduction vs fossil jet	73%-84%[3]	85%-94%[6]	99%[7]

Notes:
1. Ethanol route;
2. Oilseed bearing trees on low-ILUC (inderect land use change) degraded land or as rotational oil cover crops;
3. Excluding all edible oil crops;
4. Mainly used for gas/FT;
5. As rotational cover crops;
6. Excluding all edible sugars;
7. Up to 100% with a fully decarbonized supply chain.

Source: WEF (2021a).

The public sector has an important role to play in promoting SAF. Industry projections indicate that achieving net-zero emissions by 2050 will require a global production capacity of between 330 and 445 million tons/year of SAF, which will require a capital investment of between USD 1.1 and 1.4 trillion to build between 5,000 and 7,000 plants (ICF consulting, 2021). By way of reference, in Europe there are eight operational SAF plants and another 20 planned or under construction that, together, could supply about 3 million tons/year, equivalent to 5% of the current volume of jet fuel used on the continent (WEF, 2021b). Several factors act as obstacles to close this gap: (i) production costs significantly higher than those of conventional jet fuel; (ii) limited availability of sustainable inputs and high infrastructure costs to produce those inputs; (iii) high uncertainty and financing costs for SAF production infrastructure; and (iv) competition for resources and public incentives with other decarbonization initiatives. In this regard, measures adopted by countries include a combination of regulations, financial and non-financial incentives, and public procurement to scale up production (Box 4.10).

BOX 4.11.

Examples of instruments used to promote SAF development

1. Regulations:

- **United States:** Carbon intensity standard targets in the states of California, Washington, and Oregon.
- **Canada:** Clean Fuel Standard with references to carbon intensity, which are optional for SAF. Mandatory in British Columbia.
- **UE:** ReFuelEU (approved April 2023) with SAF blending mandate of 2% in 2025, 6% in 2030, and 70% in 2050. Mandate for PtL of 1.2% in 2030, 8% in 2040, and 28% in 2050. SAF is defined as synthetic e-fuels and biofuels, except those derived from palm oil and agricultural and fodder crops.

• **France:** SAF mandate of 1% in 2022, 2% in 2025, and 5% in 2050.

• **Germany:** PtL mandate of 0.5% in 2026, 1% in 2028, and 2% in 2030.

• **Norway:** Requires suppliers 0.5% PtL by regulation as of January 2020, with a target of 30% in 2030.

• **Sweden:** Mandated 1% SAF in 2021, raising to 30% in 2030.

• **Switzerland:** Goal to reduce CO2 emissions by 60% in 2050 with the use of SAF.

• **Colombia:** Climate Action Law requests the government to promote SAF development and use.

2. Pricing instruments:

• **United States:** Specific tax credits for SAF (USD 1.25-1.75 per gallon) between 2023-2027; USD 245 million grant program for SAF development. Illinois provides airlines with credits against state taxes of USD 1.50/gallon purchased until 2033.

• **Canada:** Low Carbon Fuels Procurement Program (2023-2031), which allocates USD 227 million to support the purchase of over 300 million liters of low-carbon shipping and aviation fuel, including SAF.

• **Singapore:** Sale of 1,000 SAF credits by the Civil Aviation Authority of Singapore, Singapore Airlines, and Temasek (one-year pilot program starting July 2022).

3. Non-financial instruments:

• **United States:** 114 grants (totaling more than USD 3.6 million) awarded by the Federal Aviation Administration to the Aviation Sustainability

Center (ASCENT) to support the SAF approval center in conducting evaluation tests to ensure that new fuels are safe for use. Sustainable Aviation Fuel From Renewable Ethanol (SAFFiRE) pilot project, led by the National Renewable Energy Laboratory, in collaboration with industry.

• **United Kingdom:** Green Fuels, Green Skies competition to select companies to receive funding for the development of the first commercial-scale SAF production plants in the United Kingdom.

• **Australia:** Support for the feasibility study prepared by Qantas Airways (2013) on Australian feedstock and production capacity for SAF.

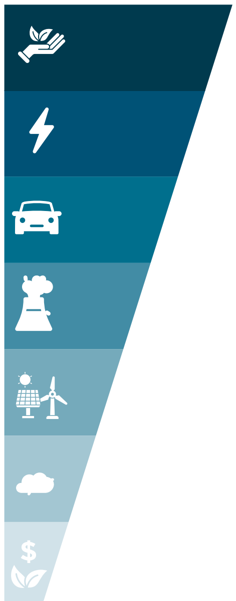
• **Global:** ICAO SAF assistance, capacity building and training program (ACT-SAF), implemented e.g. in Singapore and Kenya in 2022.

The ideal way to develop these measures begins with an invitation from governments to the sector to participate in workgroups. These are attended by representatives of the industry, financial institutions and national and international organizations, in addition to public sector entities. The purpose is to share information and best practices, and to advance in the elaboration of roadmaps to develop and promote the transition to cleaner and renewable sources of energy for aviation. In Chile, the Ministries of Transport and Energy, under the coordination of the IDB and led by the Civil Aviation Board, started a series of workshops in 2022 with the participation of private and public actors related with aviation and alternative fuel provision, with the objective of producing a roadmap for SAF development and adoption. Similarly, in March 2023 the Federal Civil Aviation Agency of Mexico launched a work plan to build a roadmap for the development of SAF, with the formation of four working groups or subgroups for the topics of Regulations, Financing and Incentives, Value Chains, and Research, with the participation of suppliers, industry, national and international organizations, government agencies, and academia.

Interinstitutional coordination is essential to align actions with the energy, environment, industry, agriculture, and trade sectors. For this reason, it is important to involve these sectors in the working groups for the development of roadmaps for the promotion of SAF. Interinstitutional coordination is also critical to identify investments in the energy sector to provide renewable energy for air transportation, as air transportation decarbonization policies are closely linked to low-carbon fuel standards and the development of energy technologies such as hydrogen. Once the technological development barriers have been overcome, the impetus must come from the political and financial support needed to ensure sufficient availability of fuels for the subsector, at a competitive price and in a timely manner.

Energy efficiency is another major area of work in the subsector to reduce CO2 emissions. Airport operations contribute an estimated 2% to 5% of total air transportation emissions (ICAO, 2019). In 2019, airport operators, grouped under the Airports Council International (ACI), committed to achieving net-zero carbon emissions by 2050. Since then, more than 130 airports have brought their target forward to 2030 or even earlier, while others have moved it to 2040. To this end, ACI has produced a guide with the different decarbonization strategies for airports, which can be divided into seven groups, as shown in Figure 4.9.

FIGURE 4.9. Airport decarbonization strategies



Grid decarbonisation	Decarbonization of electricity grids will occur at different scales and rates beyond the control of airports, however, airports can continue to purchase 100% renewable electricity through contracts with their electricity retailer if available.
Energy efficiency meansures	Continue to replace end-of-life lighting and ventilation systems with new ultra-low energy technologies paired with smart meters/automatic AI enabled control platforms with all new infrastructure to feature latest passive/ESD measures
Vehicle fleet decarbonisation	Transition light-duty vehicle fleets/GSE to 100% electric or hybrid or hydrogen fuel-cells with a progressive switch of heavy-duty vehicles/GSE to biofuels and eventually electric or hydrogen powered variants
On-site thermal descarbonisation	Start to generate electricity from cogeneration plants using biogas or biomass or from electricity supplied from renewables to power thermal plant at airports to heat and cool airport buildings more efficiently
On-site renewables	Install renewable energy systems (solar, wind, geothermal) and/or increase the capacity of existing systems, and evaluate the feasibility of battery storage technologies to enhance energy security and resilience
Negative emissions technologies	Use a combination of nature-based carbon sinks or carbon capture and storage technologies to remove any residual carbon emissions once proven and fully commercialised
Carbon offset	As an interim measure, airports can compensate residual emissions by purchasing high-quallity offsets through projects (forestry, renewable energy) that help to reduce carbon by a measurable and verifiable amount

Source: ACI (2021).

The public sector can stimulate the adoption of these measures through sustainable procurement, either through concessions or public airports. It is expected that in the future it will be increasingly common for airport concessions to include requirements on emissions inventories, as well as energy performance parameters and the use of renewable energies. Likewise, technical criteria can be used for the procurement of goods and services considering environmental metrics, encouraging purchases from suppliers that adopt criteria to reduce water and energy consumption and implement best practices in sustainability. The adoption of these measures can be facilitated by the actions that the private sector is taking to reduce its Scope 1 and 2 emissions at airport terminals. The region is no stranger to this trend. For example, the Bogota, Santo Domingo and Salvador (Brazil) airports have made progress in the installation of solar panels, the purchase of renewable energies from the national electrical system, and improvements in water conservation systems. Likewise, environmental metrics have been included as goods and services procurement criteria, encouraging purchases from suppliers who adopt measures to reduce water consumption, optimize energy consumption, make progress on development and innovation, and implement best practices in sustainability.

Another mechanism is to apply for airport accreditation from international agencies. ACI has implemented a global airport carbon management certification program (Airport Carbon Accreditation, ACA) that independently evaluates and recognizes airports' efforts to manage and reduce their carbon emissions through six levels of certification: Mapping, Reduction, Optimization, Neutrality, Transformation, and Transition (Table 4.4). Its mission is to enable the airport industry to effectively reduce its carbon footprint, to benefit from increased efficiency through reduced energy consumption, shared experience and knowledge exchange, and better communication of results. In LAC, there are currently 72 airports with some level of certification, accounting for around 48% of the region's traffic.

TABLE 4.4. **Airport carbon management certification levels (ACA)**

Certification level	Objective
Mapping: Measuring the carbon footprint	• Determine the emission sources within the airport company's operational limit. • Calculate annual carbon emissions. Prepare a carbon footprint report.
Reduction: Carbon management towards carbon footprint reduction	• Provide evidence of effective carbon management procedures. • Show quantified emission reductions.
Optimization: Involving third parties in carbon footprint reduction	• Expand the scope of the carbon footprint to include third-party emissions. • Involve third parties in and around the airport.
Neutrality: Carbon neutrality for direct emissions	• Offset the remaining emissions for all emissions over which the airport has control with high-quality carbon credits.
Transformation: Transforming airport operations and those of its trading partners to achieve absolute emission reductions	• Define a long-term carbon management strategy aimed at absolute emission reductions, aligned with Paris Agreement goals. • Show evidence of actively pushing third parties towards emission reductions.
Transition: Offsetting residual emissions with reliable offsets	• Offset residual carbon emissions over which the airport has control, using internationally recognized offsets.

Source: ACI (2023).

Digitalization of processes and procedures in passenger and freight air commercial operations generates quick wins in terms of mitigation. Digitalization improves transportation efficiency by optimizing logistics and reducing its carbon intensity, enables the shared use of infrastructure, and provides access to more accurate, real-time data to facilitate decision-making. The Chile Action Plan demonstrates the advantages of the documentation digitization process (cartography, procedures, spreadsheets) that has taken place in the country. Not only did it have an environmental impact by reducing paper and equipment weight and reducing fuel consumption, but it also provided a dynamic tool for the crews, boosting safety and allowing for greater operational efficiency. The UK's Roadmap for Aviation envisages the development of a secure technology-driven digital infrastructure and, by 2028, an increase in the number of airports integrating digital Mobility as a Service (MaaS) operations, for example through integrated ticketing and payment transfer services, to improve the interface with urban transport.

A major aspect within required public sector investments has to do with airspace design and management. Actions in this regard aim at investments in airport and air navigation infrastructure, coupled with air traffic management programs, to reduce air congestion and increase efficiency and safety in operations. In 2018, Argentina's air navigation services provider (EANA) initiated the process of redesigning the Buenos Aires Air Terminal (TMA Baires), with the help of an international consortium. TMA Baires is a congested airspace that includes seven controlled commercial, general, and military aviation airfields, which concentrates about 50% of all aircraft movements in Argentina (EANA, 2021). The new airspace concept, centered at Ezeiza International Airport, began to be validated in simulators in mid-2021 and is currently in the controller training stage for implementation in early 2024. The new concept aims to increase airspace capacity by up to 80% to meet demand growth in a safe and orderly fashion, following guidelines such as: (i) more consistent flight paths, continuous transitions, stabilized approaches, and fewer crossing points; (ii) greater predictability in operations; (iii) reduced workload for the air traffic controller and pilot; and (v) reduced trajectories, flight time, and fuel consumption.

Emission reductions can also be achieved in the airport construction process. To this end, it is key to intervene in the planning, contracting and construction phases. In the planning phase, the public sector should consider: (i) compiling an inventory of energy, material, and environmental inputs; and (ii) assessing the potential environmental impact associated with identified inputs and releases. For example, the Sustainable Airport Manual developed by the Chicago Department of Aviation aims to integrate airport-specific sustainable planning and practices early in the design process, through planning, construction, operations, maintenance, and all airport functions with minimal impact on schedule or budget (Chicago Department of Aviation, 2018). In the contracting phase, solicitations can include (i) mechanisms to incentivize companies to meet sustainability goals, whether financial or through a certificate of compliance (airports such as Los Angeles and Ontario have adopted these mechanisms); (ii) the establishment of technical specifications and standards for implementing sustainable construction practices; and (iii) requesting reports on the performance of sustainable construction practices. In this sense, there already exist construction methods that can be applied to reduce the number of products, optimize processes, and even facilitate terminal rehabilitation processes in the future under a more flexible terminal concept. Techniques that are being explored on air transportation include warm-mix asphalt (for benefits such as reduced fuel use and local pollutant emissions), recycled asphalt, and surface preservation treatments. In the construction phase, certifications such as LEED® or EDGE may be required, which promote construction methods that have an impact on emissions reduction, improve people's health, and promote a regenerative and sustainable materials cycle, among others.

While the above measures can be placed within the "Improve" pillar, there are some examples of public policies in the "Shift" pillar. The emissions impact of short-haul aviation is higher per passenger-kilometer than other modes of public transportation. It is therefore necessary, in these cases and where possible, to implement measures that encourage mode shift, for example in air travel that can be replaced by switching to high-speed rail. To have a greater impact and boost the use of this mode, additional investments and incentives are needed, as well as collaboration between subsectors (SLOCAT, 2021a). France can provide a good example of such policies, as in 2019 this country introduced an eco-tax on all domestic flights and flights leaving the country to finance the rail sector's renewal. The tax instrument is also used by Norway and Switzerland, which charge value-added taxes on international flights

–and not only domestic flights, as the other European countries do– which has an impact on the ticket price for passengers, underscoring the flight's environmental cost. This is expected to influence their decision to travel and, if so, their mode choice. However, for international and long-distance domestic travel, aviation remains the only or most feasible option. High-speed rail services, which can reduce emissions per passenger-km by up to 93%, can only replace air travel on high-demand routes and over short distances.

4.5.2 ADAPTATION MEASURES

Benchmark countries' transportation plans recognize the subsector's vulnerability to CC effects, particularly with respect to tropical storms and sea level rise. In most cases, transportation sector adaptation plans and general adaptation plans are the documents where these mentions are most prevalent, and through which resources are established to contribute to research and to the adoption of adaptation measures at airports. In the United States, for example, the Department of Transportation's Climate Action Plan provided research resources to analyze the impacts of CC at the country's airports. Similarly, in the United Kingdom, through the UK Adaptation Program, Luton and Cardiff airports assessed the risk of CC on financial and reputational aspects of their businesses, as well as their ability to deliver services in the face of external weather events (Network by WSP, 2023). These analyses are key to identify needs for public and private sector intervention to build resilience in the sector. In the UK case, the analysis at Luton and Cardiff airports led to a review of investment in capital projects, strengthening the capabilities of existing equipment, and increasing collaboration with stakeholders, including the Air Navigation Services and the Met Office. Similarly, Avinor, manager of 45 airports in Norway, conducted studies with projections of changes in climate parameters, given that most airports are located on the coast and at sea level. The studies led to the implementation of the following measures: (i) expansion of drainage systems by 50%; (ii) change of air navigation equipment batteries, located in areas with probability of flooding; and (iii) new parameters for runway construction, which must be seven meters above sea level. At the international level, in 2022, the ICAO published a guide on adaptation and resilience, which details how to include these analyses in airport planning (Box 4.11).

BOX 4.12.

ICAO's guide to adaptation and resilience of the air sector

In 2022, ICAO published its Key Steps in Aviation Organisation Climate Change Risk Assessment and Adaptation Planning (ICAO, 2022a). That guide is aimed at States, airports, aircraft operators, and air navigation service providers. The document provides guidelines for assessing CC risks through the implementation of three methodologies: (i) Scenario Planning; (ii) Real Options Analysis; and (iii) Robust Decision Making. It also provides decision tools and best practices, for example, on the importance for assessments to include climate impact on personnel, passengers, and equipment in general, in addition to operations and infrastructure, and of involving asset operators throughout the assessment.

The regulatory framework has been modified to include adaptation measures, adjusting, changing or improving air traffic operations and airport infrastructure. Design standards and the relocation of infrastructure away from higher risk areas are the most widely implemented guidelines, with particular attention to the design of runways and taxiways, reinforcing, elevating, or extending them. London Heathrow and Hong Kong airports are international examples in this regard. Other measures include: weather monitoring through real instrumentation or remote sensing; early warning systems; preventive measures such as fuel, electricity and water storage; adjustments to operations schedules; development of contingency plans and resilient operating procedures; measures to increase robustness and flexibility of operations and decision making; zoning changes based on risk assessment; and soft measures such as information sharing and training (ICAO, 2018). Given that, in most cases, airports are operated by concessionaires, these requirements can be incorporated into bidding processes and concession contracts to prioritize them, and ensure their compliance.

Within public sector instruments, information generation and dissemination are widely implemented measures to reduce disaster risks. A paradigmatic case in this regard is Hong Kong, where its Airport Authority worked with the Weather Observatory and Traffic Control to generate an operational contingency system. When Hurricane Hato hit the city in August 2017, a massive communication plan alerted the population and users through digital screens in terminals, public announcements in local media, the airport website and mobile app, among others. This allowed airlines, airports, and associated services to form an emergency group to meet the needs of passengers at airports and reschedule flights. The following day, it was possible to coordinate full passenger service, with a record number of flights. Other investments relate to the installation of automated weather stations, which allow early detection of weather phenomena that may affect airport operations.

A good practice to highlight is the combination of measures to give greater impetus to CC mitigation and adaptation. Several airports around the world are already integrating sustainable practices as a pillar within their strategic plans. Heathrow Airport's sustainability strategy (Heathrow 2.0) is a clear example of comprehensive interventions aimed at reducing the environmental impacts of airport activity and improving the quality of life of airport users and geographical environments. This strategy, launched in February 2022, aims to achieve net-zero emissions from airport operations and make Heathrow a good place to live and work (Heathrow, 2023). To this end, targets are set for 2030 to reduce carbon emissions from aviation activity by 15% and from ground activity by 45%, compared to 2019 levels. In terms of quality of life, the strategy aims to reduce suspended NOx by 18% compared to the 2019 level, limit community noise nuisance, and maximize material recycling at Heathrow. To achieve these goals, the airport has been monitoring its carbon footprint year after year, making investments in infrastructure and operational changes, and engaging industry partners. In this context, some airlines have committed to using at least 10% SAF in their operations and turning off engines when aircrafts are idling. Measures on the ground include promoting public transportation for users and employees by expanding service supply, replacing the internal combustion fleet with zero-emission vehicles, and generating energy through renewable sources such as solar panels and biomass.

Table 4.5 below shows the most commonly used measures by the sector's benchmark countries at the global level, against which to compare the state of this issue in LAC.

TABLE 4.5. **Air transportation policies implemented at international level***

Levels	Mitigation		Adaptation
	Energy efficiency	Energy transition	
Regulations	• Regulations for greater energy efficiency in construction and operation • Use of performance-based navigation procedures • Enabling MaaS for urban connections	• SAF blending requirements in fuel • Carbon intensity standards • Harmonization of regulations under CORSIA • Emission reduction targets • Regulations that encourage clean energy production by airports (i.e. photovoltaic)	• Changes in building and maintenance regulations for CC resilience • Zoning changes
Public procurement	• Emissions control in construction • Energy efficiency requirements at airports • Technical specifications and construction standards • Permits for testing new materials in construction • Participation of public airports in the ACA program	• Technical specifications and construction standards • Participation of public airports in the ACA program	• Technical specifications and construction standards consistent with CC adaptation • Investments in adaptation to CC • Development of contingency plans and resilient operating procedures
Pricing instruments	• Price attribution to GHG emissions • Emissions trading • Incentives to reduce emissions under construction	• Price attribution to GHG emissions • Emissions trading • Tax credits for SAF • Subsidies for the development and purchase of SAF • Ecotax on flights	N/A
Non-financial incentives	• Air traffic management measures, route optimization, efficient use of airspace, improvement of aircraft taxi operations	• R+D for SAF • Pilot qualification with SAF • Feasibility studies for SAF deployment	• Studies on airport vulnerability • Capacity building • R+D for solutions that increase resilience
Investments	• Emissions inventory • Air traffic management systems • Process digitalization • MaaS for urban connections	• Investment in electric rail for mode shift • Investment in SAF pilot plants	• Investments in adaptation to CC in the fields of drainage, air navigation equipment, rehabilitation • Early warning systems and protocols

Source: Prepared by the authors.

Note: *Non-exhaustive list of policies.

4.6.
Conclusions of international best practices in public policy

• Over the past ten years, benchmark countries at the international level have developed a set of policies promoting CC mitigation and adaptation in transportation. These can be summarized in five major areas of action: (i) prioritization of decarbonization and adaptation in sectoral plans and their incorporation into NDCs and other mechanisms to respond to CC; (ii) availability of a battery of instruments to promote actions on decarbonization and adaptation; (iii) institutional modernization to assume the task of planning, coordinating and supervising such actions; (iv) close collaboration and coordination with other government agencies; and (v) generation of alliances with the private sector, academia, and civil society.

• First, all benchmark countries have plans that place the fight against CC as one of the main challenges faced by the transportation sector. These plans reflect international commitments assumed by these countries for the decarbonization of transportation in the framework of the Paris Agreement, in their NDCs, and in other mechanisms provided for by the UNFCCC. They also recognize the opportunity that transportation's green transformation generates as a mechanism to boost industry, generate jobs, and make them technological benchmarks at the global level. Sectoral plans are complemented by strategies for specific subsectors and technologies. Adaptation to CC is recognized in sectoral plans as one of the top risks for transportation. Beyond NAPs, many countries have developed specific strategies by subsector, as well as for specific geographical areas.

• Second, benchmark countries use a variety of public policy instruments to foster decarbonization and transportation resilience to CC. These can be classified into five groups: (i) regulations that limit pollutant emissions and reduce vulnerability to CC; (ii) procurement processes that include environmental criteria; (iii) pricing instruments; (iv) non-financial incentives; and (v) public sector investments.

• Third, all countries have created CC mitigation and adaptation units within their sectoral agencies, where interdisciplinary teams use different approaches to analyze sectoral challenges, establish policies, and monitor them. These units have data such as emission inventories and historical series of climate variables collected and analyzed using digital technologies. The provision of resources, training, exchange of experiences at the national and international levels, and close coordination with other sectoral and governmental areas are good practices evidenced in all benchmark countries in terms of institutional capacity building to address the CC challenge.

• Fourth, given CC's crosscutting nature, goals and lines of action in the area of transportation are coordinated with entities responsible for the environment and energy. They also establish vertical coordination mechanisms between different levels of government, leveraging the powers of each level.

• Fifth, benchmark countries forge strategic alliances with the private sector, academia, and civil society to advance the decarbonization and adaptation of transportation. These start with the incorporation of these actors in the design of national and subsectoral plans through prior consultations and working groups with the public sector, and using tools such as pilots and agreements to promote innovation and technological development.

• While all subsectors have their own particularities in terms of content of the measures, the same instruments and actions are used to promote the green transition in urban mobility, road transportation, maritime transportation and air transportation, providing a reference framework for generating a big push for public policy in LAC.

5.

Roadmap for transportation decarbonisation and resilience in LAC

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Roadmap for transportation decarbonisation and resilience in LAC

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5.

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TRANSPORTATION
AND CLIMATE CHANGE

5. Roadmap for transportation decarbonisation and resilience in LAC

The climate crisis provides an opportunity to invest in a new transportation model.

Preliminary considerations

The transformation of transportation to fight against CC is a task that must begin without delay in LAC. Although the region has a much smaller share of global emissions than other regions, there are important reasons to make decarbonization and transportation resilience key public policy objectives:

• Transportation is the main contributor to LAC's GHG emissions, so countries in the region will need to take action in this sector in order to achieve the Paris Agreement goals.

• The time for action to reverse the effects of CC is running out, which means that LAC countries, in the context of just transition, must generate by 2030 the necessary enabling framework and investments to move towards net-zero transportation by 2050. They also need to meet the targets of an international regulatory framework that will be increasingly restrictive around the use of fossil fuels.

• LAC countries, especially those in the Caribbean and Central America, will be severely affected by CC, which calls for boosting transportation resilience in the region.

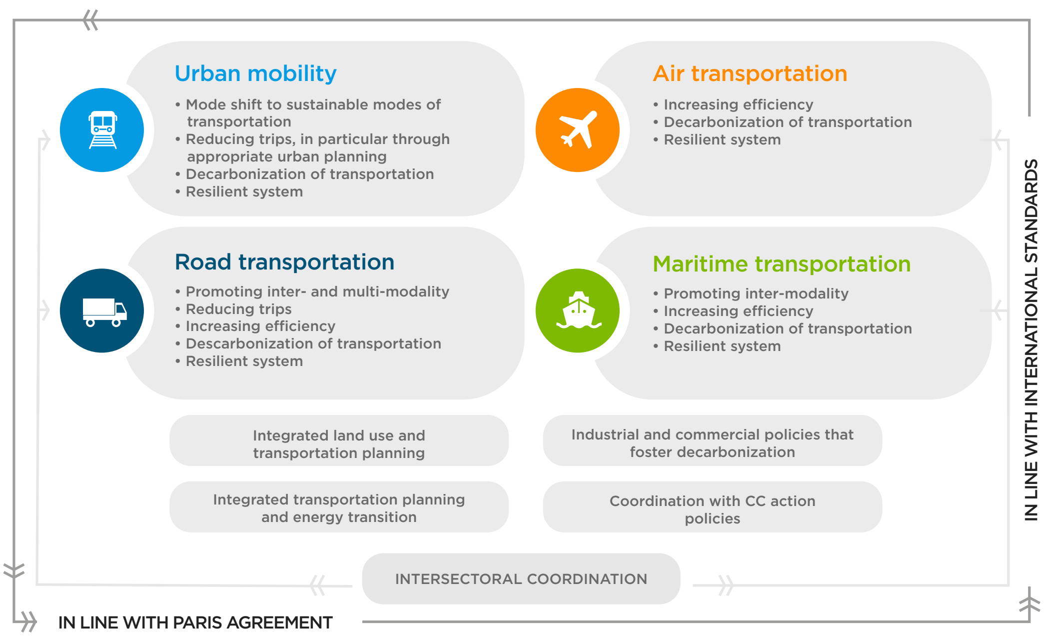
• Vulnerable populations, who have more precarious settlement and travel patterns, will be particularly affected by increased exposure to disruptions in transportation infrastructure.

• The sector's systemic transformation offers economic opportunities for the region in the form of availability of renewable energy production for transportation, strategic positioning in the reconfiguration of global transportation networks, generation of green jobs within the framework of industrial reconversion, and attraction of international investments and funds to catalyze the changes required by the sector in the fight against CC.

In general, it offers the opportunity to bet on a new transportation model that is at the service of improving the quality of life of citizens. In this regard, an important aspect to highlight is the need for a systemic vision of change, where the aim is not only to replace fossil fuels with renewable energy sources, but also to achieve more sustainable, efficient, safe and inclusive transportation that provides equal access to opportunities for all (Figure 5.1). To achieve this, as will be seen in this chapter, it is essential to take actions that generate changes in the way people and goods move, based on specific strategies for each transportation mode, coordination of actions in other areas of government, and under the umbrella of a national plan that establishes the general vision and guidelines for the sector. Clearly, the government has an important role in the materialization of this vision, but successful implementation will come from forging alliances between public agencies and with the private sector, academia, and civil society.

FIGURE 5.1.

Transportation and CC: A systemic vision



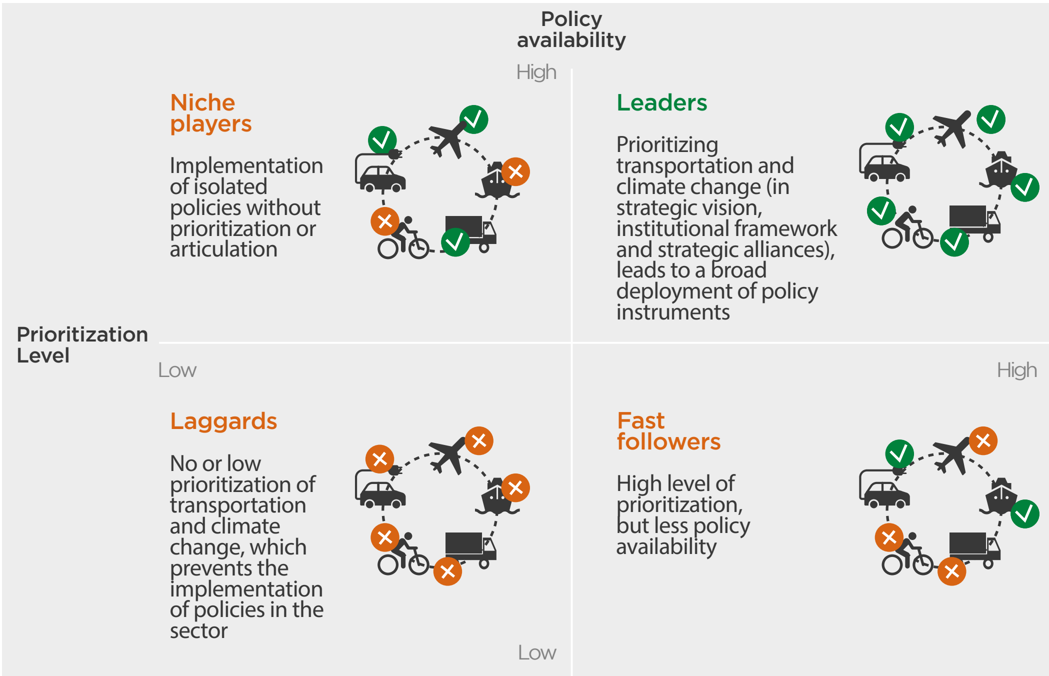
Source: Prepared by the authors.
Note: The most relevant transportation subsectors for the region are considered.

This chapter proposes four areas of action for LAC countries to generate a big push to move forward with sectoral decarbonization and resilience efforts. Based on the goals set at the international level (Chapter 3) and the best practices of countries that are leading the green transition in transportation (Chapter 4), a set of policy recommendations is presented below in the form of a roadmap. This roadmap should be implemented gradually by governments in the region, taking into consideration each country's characteristics within the framework of a just transition. These recommendations are grouped into four categories: (i) identify decarbonization and resilience as priorities for the sector, within a vision of efficient, inclusive and sustainable transportation; (ii) develop the instruments that will allow this prioritization to materialize; (iii) adapt institutions to address the task of decarbonization and resilience in the sector; and (iv) generate strategic alliances with government agencies and with the private, academic and civil society sectors, in order to promote a transition that requires a systemic change in the sector. As in the previous chapter, transportation involves different subsectors, where actions are required that may be common, but also specific to the subsector. For this reason, this chapter includes actions at the general sector level and then roadmaps for urban mobility, road transportation, maritime transportation, and air transportation.

A key aspect for the implementation of roadmaps at the level of the transportation sector and its subsectors is the initial state of each country's transportation and CC policies. We have identified two different dimensions that help visualize the heterogeneity of countries in the region: (i) the level of prioritization of transportation and CC policies; and (ii) the availability of transportation and CC policies, giving rise to four different groups of countries (Figure 5.2). The first group corresponds to the "laggards" – those countries that have not prioritized decarbonization or adaptation of transportation to CC in their strategy for the sector, and have made no progress in implementing policies in this area. The second group is the "niche players", countries that have successfully advanced in the implementation of certain policies but in isolation, without identifying CC as a strategic priority for the transportation sector, and without articulating policies. The third group corresponds to the so-called "fast followers", who have prioritized transportation and CC in their strategy for the sector, but are lagging behind in policy implementation. Finally, there are the "leaders", which have identified CC as a pillar for public policies in the sector, have a set of actions in this area, have strengthened their institutions, and have developed strategic alliances for policy success. Thus, the identification of the initial situation by each country in terms of progress in the prioritization and availability of transportation and CC policies helps adjust the roadmaps to the particular characteristics of the local reality, by detecting the areas of action that require development and strengthening.

Heterogeneity between countries is also evident in transportation's subsectors. Some cities in the region are leading the world in urban transportation fleet electrification. There are also countries that are carrying out pilots for the decarbonization of maritime transportation, while others are focusing on boosting road network resilience. Thus, for example, a country may be classified as a "niche player" in one subsector and as a "fast follower" in another. There may also be different realities within the same country, as in the case of public transportation electrification. Lastly, the technological and regulatory progress status in decarbonization and adaptation varies widely between subsectors. For this reason, this document not only analyzes the sector at a general level, but also proposes roadmaps for the region's main subsectors: urban mobility, road transportation, maritime transportation, and air transportation. To this end, an international benchmark is used as a starting point for each subsector and the proposals are adapted to the reality of LAC.

FIGURE 5.2. **Key aspects for the definition of a roadmap: Classifying countries according to level of prioritization and availability of transportation and CC policies**



Source: Prepared by the authors.

Note: A high level of CC prioritization in the transportation sector implies the development of action areas associated with the strategic vision, institutional framework, and strategic alliances. Meanwhile, a high level of policy availability implies wide deployment of the action area related with policy instruments.

It is important to recognize that, as a group of developing countries, the region has fiscal, financial, economic, and social restrictions to undertake an aggressive investment program to modify the current development model. For this reason, the transition must be gradual and just, always with the goal of achieving carbon neutrality. The just transition is recognized in the Paris Agreement, which states that the economic, social, and environmental context of each country must be considered, and emphasizes the adoption of a gradual approach for developing countries.

The just transition approach also refers to each country's contributions to CC. The richest 1% countries of the world are responsible for 17% of global CO2 emissions; the next 9% account for 31.8%; the middle 40% are

LAC must invest more and better in transportation infrastructure to achieve the SDGs.

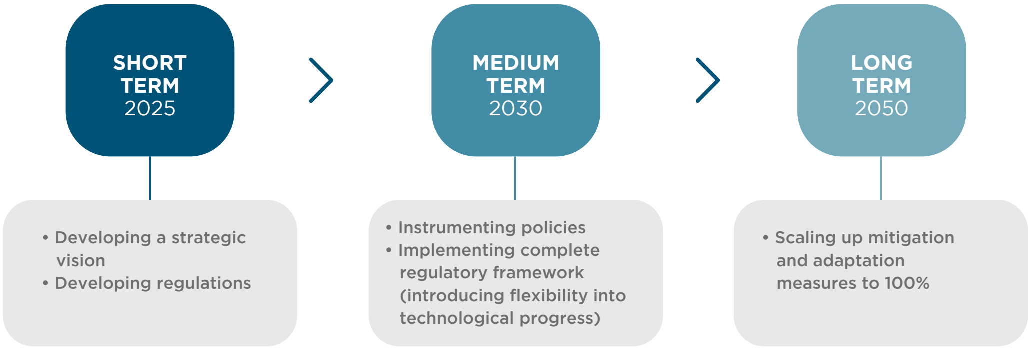
also responsible for 40% of emissions; and the poorest 50% account for just 12% (UNCTAD, 2022a). The latter are not only less responsible for global warming, but also suffer the most from its consequences (African Development Bank et al., 2003). In this context, and with particular reference to transportation, emissions in LAC amount to only 9% of global emissions in the sector (2% if global emissions from all sectors are considered), compared to 32% in Asia Pacific and 28% in North America. With 0.95 tonnes of CO2 emitted per capita in transportation in 2019, LAC is well below the average for OECD countries (2.6) and the United States (5.4) (see Chapter 1).

Thus, LAC countries must advocate internationally as a region for a just transition, in which the countries with higher levels of emissions and greater availability of resources have greater responsibility for the transition. A key aspect in this regard is to reconcile economic growth with the energy transition. Advanced economies grew on the basis of a carbon-intensive model (Awaworyi Churchill et al., 2021). In contrast, developing countries face the challenge of boosting growth in the context of CC. A just transition, as advocated by countries within the United Nations, implies recognizing that not all countries must move at the same pace in decarbonizing their economies. Advanced economies should start by making the greatest effort by 2030, allowing developing countries to gradually transition to a low-carbon growth model. Thus, emissions in this group of countries are expected to peak in 2030 - later than in advanced economies - and then begin to decline.

This has its corollary in terms of investment in the transportation sector. The region still faces a major challenge to close the transportation infrastructure gap, especially in urban mobility and roads, which limits its ability to achieve the SDGs. As scientifically shown, and recognized in benchmark countries and international organizations' strategic plans, transportation infrastructure and services are key to building more inclusive and sustainable societies (Serebrisky et al., 2020). In LAC, mass public transportation systems increase access to employment and education, while investment in road infrastructure reduces the travel times and costs of transporting goods and inputs, boosts productivity, improves access to markets, creates job opportunities, and increases the income of population benefiting from the investments, helping fight poverty (see Chapter 1). Thus, the region must invest more and better in transportation infrastructure to close the development gap. Of course, it must do so while meeting its emission reduction targets in a context of gradual transition.

In LAC countries, a gradual transition involves implementing actions in the short, medium, and long term. In the short term, the countries must develop a strategic vision and a regulatory framework that enables the transition. In the medium term, they must enact policies and programs to enable the scaling up of measures, and in the long term, they must achieve carbon neutrality and strengthen the resilience of the sector by 2050 (Figure 5.3).

FIGURE 5.3. **Definition of main targets for decarbonization and adaptation of transportation to CC in the region**



Source: Prepared by the authors.

In this chapter, the recommended actions for the region are divided into five sections: (i) general actions to prioritize the issue in the sectoral plan and identify funding and financing sources; (ii) actions for urban mobility; (iii) actions for road transportation; (iv) actions for maritime transportation; and (v) actions for air transportation. These are further divided into short-, medium-, and long-term actions to provide a temporal prioritization of the actions. The measures are accompanied by examples from the region and boxes providing information on important aspects of the recommended actions.

5.1.
General actions: Prioritization in the sectoral plan and identification of funding and financing sources for the development of clean and resilient transportation systems

A fundamental action to promote transportation decarbonization and resilience is to identify them as priority goals for the sector. This requires changes in planning instruments. The main document to adjust is the National Transportation Plan or similar, which must specify the importance of these aspects for the future of transportation in all its modes, as well as for the achievement Paris Agreement goals and the promotion of an environmentally friendly development model. The Plan should set out the vision on top of which specific plans and instruments can be generated for different transportation modes, as presented in the sections below. This should be done by the authority in charge of the sector, in coordination with environmental and energy authorities. Also, the priorities should be consistent with the goals set out in the country's NDCs. The priorities to be identified in the Plan can be summarized as indicated in Figure 5.4.

FIGURE 5.4. **Strategic priorities in planning the transportation sector's decarbonization and adaptation to CC**

Promoting sustainable mobility

- Support the transition to zero-emission vehicles ("improve" pillar)
- Encourage measures to reduce trips and shift to more sustainable modes, both for passengers and freight
- Strengthen road safety
- Promote the inclusion of vulnerable populations
- Close the gap between large, medium and small cities, providing quality mobility for citizens

Reducing the global carbon footprint of transportation

- Consider the full life cycle assessment of projects
- Encourage inter- and multi-modality for passengers and freight
- Consider international and local measures for the aviation and maritime sectors
- Link transportation to the energy transition and its impact on the national economy
- Use nature-based solutions to enhance the transportation sector's adaptation to climate change and mitigation of its impacts

Strengthening the resilience of systems

- Generate information and early warning systems
- Develop scenarios and adopt methodologies of decision making under deep uncertainty
- Combine soft actions (regulatory framework) and hard actions (infrastructure investments)

Investing in innovation & technology

- Encourage R&D in technologies for sustainability and climate resilience
- Promote pilots and regulatory sandboxes for testing technologies
- Establish partnerships with the private sector, academia, and international cooperation to capitalize on quick-wins

Source: Prepared by the authors.

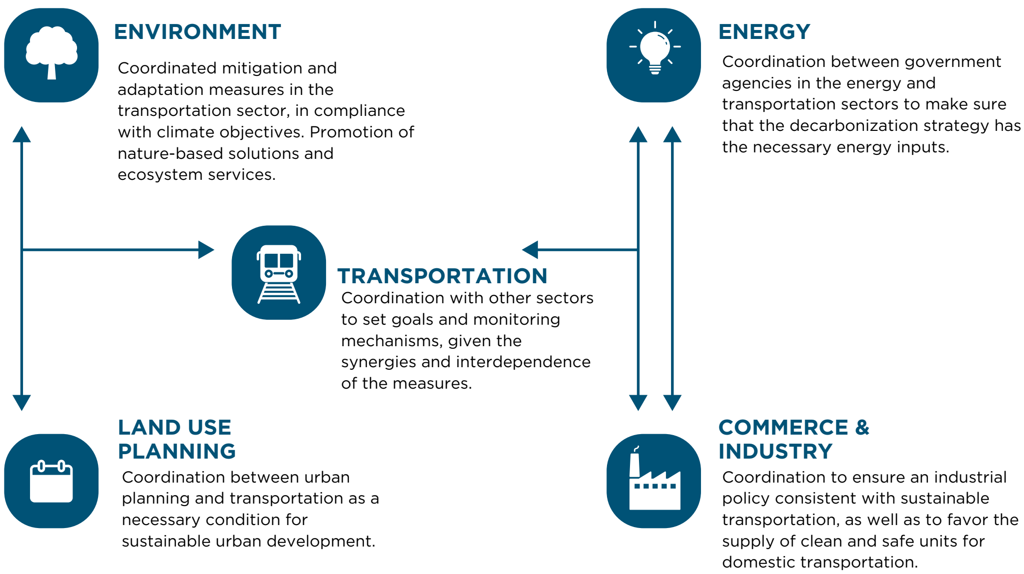
The preparation of prospective documents and technical studies on the sector's impact on CC and vice versa is useful for identifying policy actions to be included in the Plan. These documents can be developed by the public sector or be requested from the private and/or academic sector via public procurement. Numerous international organizations provide resources to finance these studies, which identify scenarios, opportunities, barriers, and lines of action for public policy, serving as input for sectoral plans and strategies. International cooperation can also be useful to inform the modification of the plan, as it allows accessing the experiences of benchmark countries and peers in the region with respect to best practices and lessons learned in the design and implementation of national, subsector, and technology- specific plans.

Preparation and modification of the Plan must include a process of consultation with relevant stakeholders. These consultations should take place before, during, and after the preparation of the plan. The private sector, civil society, academia, and other public agencies dealing with

CC related aspects should be included in this process. Among other actions, roundtables on specific topics, calls for citizen proposals, and focus groups or surveys could be considered. A mechanism adopted by several benchmark countries is the formation of a high-level advisory committee for the Plan modification, which includes national and international experts.

Given CC's cross-cutting nature, it is important to define the role of government agencies in the implementation of the Plan. In general, the Ministries of Environment establish guidelines on the goals to be achieved in the fight against CC. According to these guidelines, the Ministries of Transportation identify the objectives and actions for the sector, while the Ministries of Energy do the same on the energy transition. Given the interdependence of measures in the three sectors, it is essential to establish coordination mechanisms among them and to identify common goals and progress monitoring mechanisms, in addition to coordination with territorial planning (Figure 5.5).

FIGURE 5.5. **Cross-sectoral coordination and synergies for decarbonization and adaptation of the transportation sector**



Source: Prepared by the authors.

LAC must invest 3.12% of its GDP annually in infrastructure to meet the SDGs.

Having renewable energy sources is crucial for transportation decarbonization. This requires close collaboration with the energy sector, which should be specified in the Plan. Transportation decarbonization will go hand in hand with the availability of large amounts of renewable energy and critical minerals, complementary infrastructure, and innovations in energy storage technologies, among others. Although the region is a world leader in terms of renewables, scaling up the energy transition poses significant challenges, for example in terms of environmental and social aspects for hydroelectric generation, sustainability and resource competition for biofuels, and weather variability for wind energy due to CC. Likewise, not all countries have the same potential for renewables – for example, Caribbean nations lack sufficient surface area and must focus on developing offshore renewables. Green fuels such as hydrogen and its derivatives require adaptation in infrastructure and supply chains. In short, the dimension of change in the energy sector is significant, involving a paradigm shift and, consequently, time and substantial investments to advance in the large-scale production of zero fuels and zero net emissions. For this reason, transportation decarbonization cannot be considered without integrated planning with the energy sector.

Funding and financing mechanisms are key aspects that should be mentioned in the Plan at the general sector level to allow investing and generating the enabling policy framework for transportation decarbonization and resilience. The region has major deficits in terms of modern, efficient and sustainable transportation infrastructure to provide the services needed by citizens and businesses. If LAC is to meet the SDGs by 2030, it will need to invest at least 3.12% of its GDP annually in economic infrastructure (water, energy, telecommunications, and transportation), to close in time the USD 2.2 trillion annual gap in associated assets (Brichetti et al., 2021). The transportation sector accounts for the largest share of the estimated gap – 44% of the total amount –, implying that the region will need to invest about USD 1 trillion annually in transportation to achieve the SDG targets (Brichetti et al., 2021). In addition, demand for resources from the sector is expected to rise due to greater needs for infrastructure maintenance and replacement because of CC effects, and for resources to decarbonize transportation. However, if adaptation measures are included from the planning stage, they represent a minimal cost relative to infrastructure investment. For example, in Europe, estimates of future adaptation costs of bridges and roads are between 0.2% and 1.5% of maintenance costs, if considered from the planning stage (Nemry & Demirel, 2012).

There are different funding alternatives for transportation in the region. These can be classified according to who pays and who benefits from the services provided. Table 5.1 ranks them according to the proximity between the beneficiaries of the service and those who fund the associated costs.

TABLE 5.1. **Instruments to fund transportation infrastructure assets in LAC**

	Instrument	Typical examples in the transportation sector	Limits to funding
Charges to direct users of the services	Full fare	• User fees at ports and airports • Tolls at urban highways	• Underlying demand
	Cross- subsidized fee	• Urban public transportation fares • Single fare for a set of infrastructures (e.g. international boarding tax used to finance airport network)	• Underlying demand • Substitutability
Charges to indirect beneficiaries of the services	Sectoral funds	• Fuel funds for the road network	• Underlying demand • Substitutability
	Value capture mechanisms	• Mechanisms used for funding subway works • Revenue on commercial operations at public transportation stations • Regulations for granting building permits to real estate developers, requiring contributions to investments in public transportation	• Creation of value associated with the project • Availability of appropriate financial instruments
Funding not linked to the service	Intersectoral funds		• Funding service demand • Funding service productivity
	Specific purpose funds	• Fees on productive activities (mining, oil, etc.)	• Fund “feeding” sources
	General funds	• Taxes	• Fiscal space • Shadow cost of public funds • Productivity of the economy

Source: Prepared by the authors.

Despite being the most efficient, charges to the direct beneficiaries of services through full fares are scarce. These are concentrated in certain subsectors, such as the port or airport sectors. Given the presence of economies of scale, externalities, and distributive objectives (particularly in services considered basic, such as urban mobility), additional sources of funding are required to guarantee access to services, such as cross-subsidies. These subsidies have been used in the region and seek to discriminate between the different funding capacities of users to increase the available funds. However, the funding capacity through these subsidies is limited because, as fee differentials increase, distortions in consumption decisions also increase, becoming more costly, affecting service consumption and investment in substitute services.

Charges to indirect beneficiaries constitute an alternative funding instrument when it is impossible to obtain sufficient funds through direct beneficiaries. A typical case in LAC is the creation of funds for road infrastructure financed through taxes or charges on the sale of liquid fuels. Given the difficulty of adequately identifying and charging beneficiaries for the use of each section of the road network (due to technological issues or associated costs), funds can be obtained through users who benefit indirectly from the existence of the road network. Another example of funding through indirect beneficiaries is the use of value capture mechanisms – much less common in LAC, although there are successful cases in Colombia –, which make it possible to fund the construction of assets through appropriation of the value generated by their availability rather than their use. Construction and improvement of public transportation networks, for example, increase the valuation of neighboring properties, which can be captured through taxes or differential rates.

Regarding financing, the transportation sector has various alternatives of financial sources and instruments. There are different financial entities investing in transportation projects, including: (i) governments; (ii) state-owned enterprises (SOEs); (iii) multilateral financial institutions; and (iv) private investors (such as private developers, infrastructure funds, pension funds, banks, etc.). Each of the financial entities may use different financial instruments, including: (i) non-reimbursable funds; (ii) debt (the most common instruments being loans and bonds - Box 5.1); and (iii) capital contributions (Vassallo & Garrido, 2023).

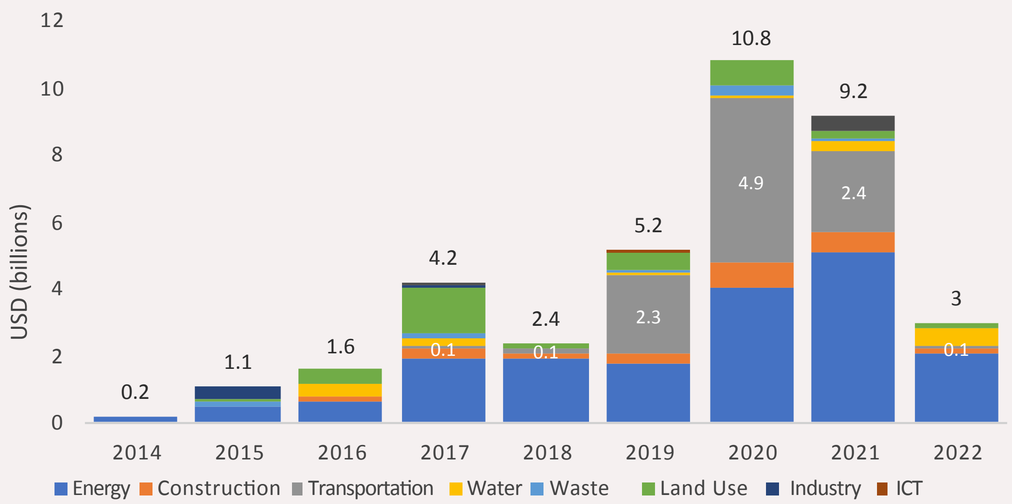
BOX 5.1.

Green transportation bonds in LAC

Green bonds are "debt financing or refinancing instruments, issued by companies, financial, non-financial or public entities, where the resources raised are 100% used to finance green assets and projects" (Barreto, 2019). According to the database prepared by the Climate Bonds Initiative (CBI), the total amount of Green Bonds issued in LAC has been USD 37.7 billion in the period 2014-2022, of which the transportation sector represents 26% (USD 9.9 billion). The record year for the transportation sector in the region was 2020, with a total of USD 4.9 billion of Green Bonds issued.

FIGURE 5.1.1.

Green Bonds by sector in LAC (2014-2022)



Source: Prepared by the authors based on CBI (2022).
Note: Unspecified adaptation and resilience bonds (USD 0.6 billion for the period) are not included.

LAC receives 29% of the climate funds available for the transportation sector at the global level.

Securing financing and funding for clean and resilient transportation infrastructure and services is a challenge for the region due to the incipient nature of certain technologies, hence the importance of climate funds. Despite the potential of private capital to reduce transportation infrastructure gaps, the uncertainty associated with new technologies in the sector – both for adaptation and mitigation – represents a limitation to unlock this source of financing. In this sense, investors can expect higher returns as compensation for the risk associated with emerging technologies. For example, despite the advantages of electric vehicles, the technology is still very incipient in developing countries due to cost overruns – sometimes over 70% compared to conventional vehicles – which is a financial barrier for many consumers (Briceno-Garmendia et al., 2022). Thus, many of the new technologies require greater government support in the early stages to accelerate their development, until they can become competitive and scalable. In a context of fiscal constraints – exacerbated by the impacts of the COVID-19 pandemic and the international situation – climate funds play a key role in supporting governments in ensuring the initial impetus for the development of CC mitigation and adaptation policies in the transportation sector.

Climate finance for the transportation sector in LAC, from different climate funds, is still incipient. It is possible to identify different climate finance funds in the region for the transportation sector (Table 5.2), mostly focused on CC mitigation, mainly from multilateral funds and initiatives (GCF, CTF, GEF, PMR, SREP, and PPCR), but also from bilateral financing (IKI and Nama Facility). The total amount of climate finance for the transportation sector in LAC represents 29% of the total finance granted in the sector at the global level (Figure 5.6), totaling USD 840 million in the region in the period 2000-2022 (Figure 5.7). The GCF is the leading climate finance fund in LAC, accounting for 65% of the total, while together with the CTF and the GEF, it represents 91% of total financing. The growth in the amounts financed by the GCF in the years 2021-2022 has been exponential in relation to previous years (Figure 5.8), led by the recent approval of the electric mobility programs in the region by the IDB (Financing Proposal FP189) and CAF (FP195). In general, climate funds have considered adaptation to a lesser extent. In the case of the GCF, half of the projects cover adaptation and mitigation, while the other half focus only on mitigation.

However, there has been a change in trend in the GCF programs, with a greater focus on adaptation in the most recently approved programs (such as the IDB's electric mobility program, FP189), both in terms of volume financed and concessionality. For its part, the GEF, only from the seventh replenishment of trust fund resources in 2018 (GEF-7), began to identify the Rio Markers of adaptation and mitigation to CC. Of the total of 27 projects approved in the region during GEF-7, only one includes adaptation activities. Lastly, each of the funds has different instruments, including concessional loans, non-reimbursable funds, and capital contributions, among others.

TABLE 5.2. Detail of climate financing in LAC's transportation sector

Fund	Details
Green Climate Fund (GCF)	• **Operating entity:** The GCF is legally an independent institution. • **Category:** Adaptation, Mitigation. • **Objectives:** Contribute to the achievement of the overarching objective of the UNFCCC, promoting a paradigm shift towards low emissions and climate-resilient development pathways, and support developing countries' efforts to limit or reduce GHG emissions and adapt to the impacts of CC.
Clean Technology Fund (CTF)	• **Operating entity:** World Bank. • **Category:** Mitigation. • **Objectives:** To promote greater scale of financing for the demonstration, deployment, and transfer of low-carbon technologies with significant potential for long-term GHG savings.
Global Environment Facility (GEF)	• **Operating entity:** World Bank. • **Category:** Adaptation, Mitigation. • **Objectives:** GEF funds are available to developing countries seeking to meet the goals of international environmental agreements. To provide support to government agencies, civil society organizations, private sector companies, research institutions and other partners to implement projects and programs related to environmental conservation, protection, and renovation.
International Climate Initiative (IKI)	• **Operating entity:** Government of Germany (BMU). • **Category:** Adaptation, Mitigation. • **Objectives:** Promote a climate-friendly economy, measures to adapt to the impacts of CC and measures for the preservation and sustainable use of carbon stocks / Reduction of Emissions from Deforestation and Degradation (REDD+).
NAMA Facility	• **Operating entity:** German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU); UK Department of Business, Energy, and Industrial Strategy (BEIS); Danish Ministry of Energy, Utilities and Climate (EFKM); European Commission. • **Category:** Mitigation. • **Objectives:** NAMA Facility funds projects that support NAMAs, which are innovative, mitigation- focused, address CC, and have the potential to scale up and take advantage of the opportunity to build resilient and sustainable economies. Mitigation Action Facility is the continuation of NAMA Facility, which was active from 2012 to early 2023.

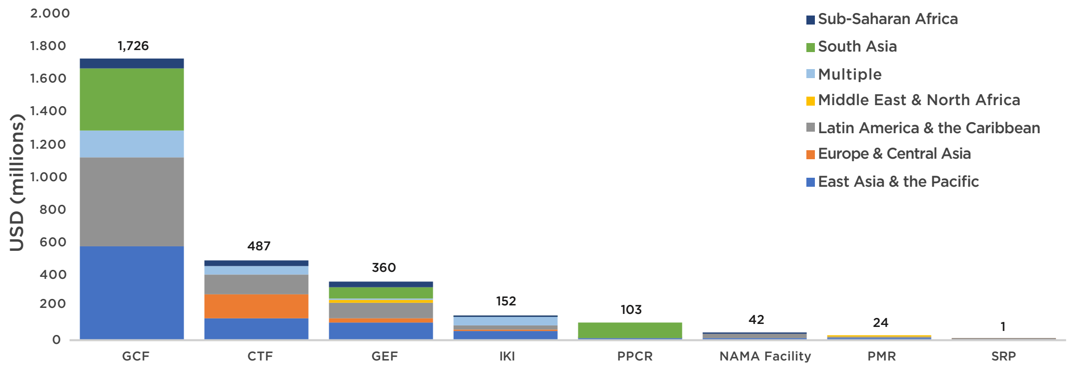
Fund	Details
Partnership for Market Readiness (PMR)	• **Operating entity:** World Bank. • **Category:** Mitigation. • **Objectives:** To create market readiness and implement market-based instruments such as national emissions trading systems (ETS) and accreditation mechanisms.
Scaling up Renewable Energy Program in Low Income Countries (SREP)	• **Operating entity:** World Bank. • **Category:** Mitigation. • **Objectives:** Support investments to help low-income countries reduce greenhouse gas emissions and benefit from their renewable energy resources.
Pilot Program for Climate Resilience (PPCR)	• **Operating entity:** World Bank. • **Category:** Adaptation. • **Objectives:** Promote and demonstrate approaches for integrating climate risk and resilience into development and planning policies; strengthen capacities at the national level to integrate adaptation to CC into development planning, scale up and leverage investment in climate resilience, build on other ongoing initiatives, enable learning by doing and exchange lessons at national, regional, and global levels.

Source: Prepared by the authors based on GEF (2023b), REGATTA (2023), and Watson et al. (2023).

Note: *There are other climate funds available in the region that: (i) do not directly cover the transportation sector, including Amazon Fund, Forest Investment Program (FIP), Forest Carbon Partnership Facility (FCPF), UN-REDD Programme, BioCarbon Fund, Adaptation for Smallholder Agriculture Programme (ASAP), Millennium Development Goal Achievement Fund (MDG-F), Norway´s International Climate and Forest Initiative (NICIFI), and REDD+ Early Movers (REM); or (ii) to date there are no projects in the sector, or it is not possible to identify projects at the country level, including Adaptation Fund (AF), Special Climate Change Fund (SCCF), Global Energy Efficiency and Renewable Energy Fund (GEEREF), Global Climate Change Alliance (GCCA), Least Developed Countries Fund, Global Climate Partnership Fund (GCPF), and International Climate Finance (ICF).

FIGURE 5.6.

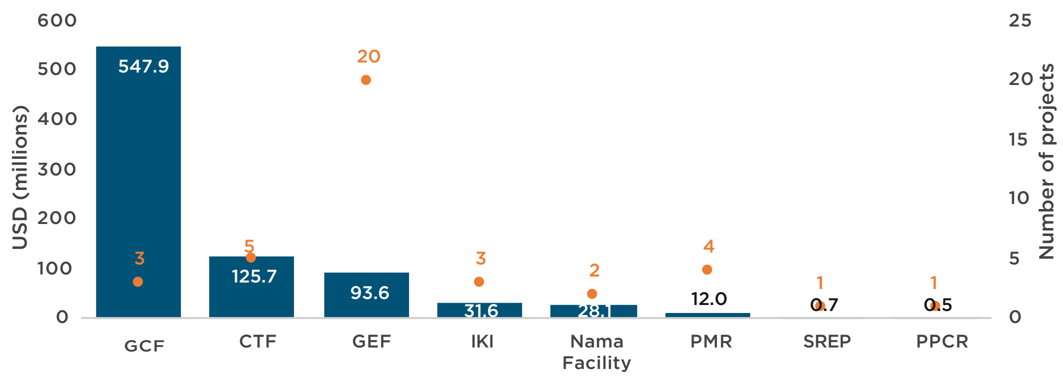
Total amount of climate funds in the transportation sector by region (2000-2022)



Source: Prepared by the authors based on projects' data from GCF (2023), CIF (2023), GEF (2023a), Mitigation Action Facility (2023), PMR (2019), and IKI (2023).

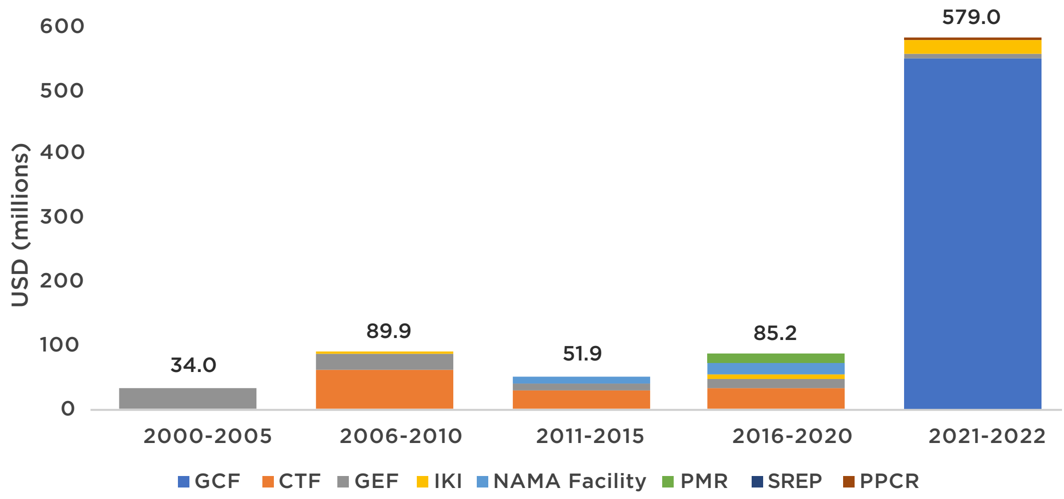
FIGURE 5.7.

Climate funds in LAC's transportation sector (2000-2022)



Source: Prepared by the authors based on projects' data from GCF (2023), CIF (2023), GEF (2023a), Mitigation Action Facility (2023), PMR (2019), and IKI (2023).

FIGURE 5.8. **Historical evolution of climate funds in LAC's transportation sector (2000-2022)**



Source: Prepared by the authors based on projects' data from GCF (2023), CIF (2023), GEF (2023a), Mitigation Action Facility (2023), PMR (2019), and IKI (2023).

Note: This graphic considers the projects' year of approval.

The joint development and implementation of a set of funding and financing mechanisms can help ensure that the sector has the necessary resources to develop efficient, inclusive, and sustainable transportation systems, and continue to meet the needs of the region's population and business fabric in an environment of fiscal and economic constraints. To close gaps in the sector, it is necessary to allocate a greater volume of resources, improve the efficiency in the use of funds and the instruments used, and explore innovative funding and financing mechanisms. First, it is imperative to improve efficiency in the use of currently available funds, that is, to maximize the return on each investment unit through effective management and careful execution of projects. Second, it is necessary to seek alternatives to increase funding for transportation infrastructure through mechanisms already in use, such as eliminating fossil fuel subsidies, replacing general subsidies with subsidies focused on interest groups, or allowing the adjustment of public transportation fares. Third, innovative funding mechanisms that are still little used in the region should be explored. These include value capture mechanisms, which allow recovering part of the capital gains generated by infrastructure (and help financing system improvements through land use planning that encourages development in transit-connected areas); new business models in the case of electric public transportation (such as the separation of ownership and operation of buses); or climate funds, which allocate resources for projects that contribute to CC mitigation and adaptation to its effects, including concessional loans and capital contributions. Investing in adaptation is critical to reduce the risk associated with infrastructure projects and make them bankable, ensuring greater availability of climate fund resources that can be effectively targeted to the most appropriate regions. Finally, innovations in financing, such as structured financial incentives and the creation of scale through coalitions of sponsors, can help attract private sector investment, in addition to promoting CC-sensitive public-private partnerships in the sector.

Electric mobility is gaining momentum in the region, with Chile and Colombia leading the way in the electrification of public transportation.

5.2.
Roadmap for decarbonization and resilience of urban mobility

The region has made progress in the decarbonization of urban transportation mainly through the push for electric mobility ("Improve" pillar within the "Avoid-Shift-Improve" approach). In terms of the legal framework, several regional countries have national electric mobility strategies or are in the process of developing their plans or strategies, while some have also advanced in the development of energy efficiency standards. Regarding the interoperability of electric vehicle charging – a fundamental link for scaling up at the national and regional levels – some countries, such as Chile, Colombia, and Uruguay, already have regulations in place. On the other hand, most countries have incentives for the entry or use of electric vehicles. This favorable framework for electric mobility has allowed, in the case of public transportation, for example, to double the number of buses in the period 2020-2023, from 1,959 units in 2020 to 4,128 in February 2023 (E-BUS RADAR, 2023), led by the electrification process of public transportation in Chile and Colombia. However, as will be seen in the actions proposed below, there are still significant technological, financial, and institutional barriers to achieving the massification of electric public transportation in the region.

Informal and semi-formal transportation and private motorcycle transportation have received limited attention in decarbonization strategies. Despite the importance of promoting a sustainable transportation system based on formal public transportation and active mobility, the sector's energy transition must encompass all modes of transportation. Informal and semi-formal transportation account for more than half of public transportation trips in LAC and provide coverage mainly in peripheral areas where lower-income sectors live (Tun et al., 2020). In the case of motorcycles, despite their undesirable impacts in terms of air and noise pollution, road safety and driving patterns, they occupy a very relevant place in mobility in the region, particularly in the lower and middle-income sectors. In Colombia, for example, 73% of all vehicles registered in the first half of 2021 were motorcycles. In the Dominican Republic, they accounted for 56% of registrations in 2020. In Uruguay, motorcycles represent 51% of the vehicle fleet (Azzato et al., 2022). The COVID-19 pandemic has also driven the motorcycle expansion through the growth of home deliveries. Despite this growth, electric mobility initiatives for motorcycles are incipient in LAC. In 2022, Uruguay implemented a benefits program for the incorporation of electric motorcycles and tricycles (up to 1,000 and 100 units, respectively) known as “Subite” (“Hop on”), which includes the reimbursement of part of the purchase value of the vehicle, discount on electricity, reimbursements for energy savings, and benefits in mandatory insurance (MIEM, 2023). It is therefore essential to integrate these segments into the general transportation system so that, together with their formalization and electrification, they can contribute to reduce car dependence and emissions.

Actions in the “Avoid” and “Shift” pillars have also contributed to emission reductions in the sector. The region has made significant headway in these pillars through investment in physical infrastructure for public transportation (including the implementation and expansion of BRTs, metros, and cable cars), and active transportation (through the expansion of cycling and pedestrian infrastructure and the implementation of public bicycle sharing systems), as well as through planning, mainly with the development of Sustainable Urban Mobility Plans. In this context, it is important to highlight that, to drive the systemic transformation of urban mobility towards a more sustainable mobility, electrification strategies are not enough, but actions are required throughout the entire “Avoid-Shift-Improve” framework. Indeed, it is in the “Shift” pillar where governments have the greatest range of action through regulations, investments, and reallocation of public space to encourage collective mobility as opposed to the use of private vehicles (Rode et al., 2019).

Countries and cities in the region have contemplated different measures to adapt to the impacts of CC for urban mobility. Although, in general terms, adaptation measures have received less attention than mitigation measures, they have been included in national plans, strategies, and official documents, but particularly in instruments for specific cities or regions. In the case of transportation infrastructure, adaptation measures focus on NBSs to cope with the effects of extreme weather events associated with high temperatures and precipitation, both for the climate resilience of the project and for the benefit of users (Box 5.2) (for more detail on these effects, see Chapter 1).

Adaptation and mitigation actions are closely related and should be addressed jointly in LAC's urban mobility decarbonization. Advancing CC adaptation is essential not only to minimize potential damages and losses from extreme events, but also to support mode shift strategies towards public transportation and active modes. For example, public transportation systems must be capable of responding effectively to extreme hydrometeorological events to be attractive compared to other, more polluting modes of transportation, guaranteeing a safe, reliable and comfortable service. Similarly, some actions aimed at reducing emissions can improve transportation systems resilience. For example, electrification of buses and stations is a strategy that accelerates the transition to renewable energy sources, while at the same time their batteries provide extra energy storage capacity that boosts system resilience to extreme events by providing emergency power and increasing system stability.

BOX 5.2.

Planned adaptation measures in LAC's urban transportation

Planned measures reveal countries' intentions to adapt urban transportation to the effects of CC through their explicit inclusion in official national or subnational documents. Analysis of the region shows that there are a variety of measures in this area, highlighting those focused on physical infrastructure and, in particular, NBS (Table 5.2.1). These NBS include the restoration or creation of ecosystems, and the use of trees, vegetation, and green infrastructure.

TABLE 5.2.1.

Planned adaptation measures in LAC countries' physical transportation infrastructure*

Types of planned measures	Countries
• **Planting trees and vegetation to increase evapotranspiration and shade NBS**	• El Salvador • Honduras • Mexico • Peru • Dominican Republic

• **Improve drainage system**	• El Salvador
• **Using green infrastructure to divert water and increase infiltration NBS**	• El Salvador • Paraguay • Uruguay
• **Restoration of floodplains, trees, vegetation, permeable natural surfaces, and water bodies for the slowing, reduction, and storage of runoff NBS**	• El Salvador • Uruguay
• **Ecosystems restauration or creation NBS**	• Brazil • Colombia • Peru

Source: Prepared by the authors based on Rivas et al. (2023).
Note: Non-exhaustive list.

Even with these advances, LAC countries are in general far from those achieved in Europe, North America and Asia. Closing this gap requires a roadmap for the subsector's decarbonization and adaptation to CC that, leveraging the international best practices identified in Chapter 4, is consistent with the particular traits of the region and maximizes its potential to contribute to sustainability. In this regard, the suggested policy actions are presented below, organized into the four categories used in this chapter to propose the roadmap: (i) strategic vision; (ii) policy instruments; (iii) institutional framework; and (iv) strategic alliances. Additionally, to provide a time frame for implementation, actions are classified into short, medium, and long term.

5.2.1 STRATEGIC VISION

The first action in the roadmap should be to place decarbonization and resilience as public policy priorities in urban mobility, identifying goals for the subsector. This action should be carried out in the short term, since it is then followed by defining tasks and allocating budgets to achieve the established objectives. At the institutional level, due to the division of functions in urban mobility, this is the responsibility of both national and local authorities, so ensuring vertical coordination is key. The table below summarizes the suggested actions to position decarbonization and resilience within the strategic vision of urban mobility.

Temporality	Action
Short term (2025)	• Prepare prospective studies on the opportunities and impacts of decarbonization of the subsector in terms of efficiency, mobility management, competitiveness, and inclusion. As part of these studies, identify scenarios, opportunities, barriers, and lines of action for public policy, serving as input for plans and strategies • Identify CC risks on urban mobility transportation infrastructure and services with a systems vision and assessing the structural and functional vulnerability of the different components of the defined transportation systems • Conduct consultations with stakeholders from the urban mobility sector, logistics, energy, academia, public agencies, civil society, and other stakeholders, with a view of incorporating CC into transportation and urban mobility plans • Improve urban transportation infrastructure planning and decision-making processes so that uncertainties associated with the temporal distribution of projected CC impacts and their intensity are efficiently managed • Modify the sectoral transportation plan and urban mobility and logistics plans so that they include the most vulnerable areas of the country and the projected impacts of CC by region, establishing the vision for the future and the main lines of action for monitoring and managing CC response actions, energy sources, intermodality, coordination with other sectors, etc. • Develop a CC action plan for the subsector, with broad participation of the different stakeholders and, based on previous analysis and consultations, establish a roadmap with concrete measures to promote decarbonization and adaptation (see subsection on instruments) • Establish emission reduction targets for the subsector, in coordination with local authorities
Medium term (2030)	• Evaluate and, where appropriate, modify GHG emission reduction targets for the subsector, in coordination with local authorities

BOX 5.3.

Decarbonization of public transportation in the region: prioritization, goals, and instruments

Throughout the region, national and local governments have modified or established sustainable urban mobility plans with the aim of achieving more environmentally friendly, efficient, safe, and inclusive transportation that provides equal access to opportunities for all. To this end, a mode shift towards public and active transportation is promoted, redistributing public space in favor of these modes, investing in infrastructure and service improvements, and discouraging the use of private vehicles.

In this context, public transportation electrification has become a central issue in the decarbonization agendas of several countries in the region. Chile and Costa Rica have set the most ambitious targets in terms of coverage, by targeting the complete decarbonization of their public transportation fleets by 2050 (Table 5.3.1). At the subnational level, several cities have set targets to reach 100% of public transportation with electric buses by 2035, including Bogota, Cuenca, Salvador, and Santiago de Chile.

TABLE 5.3.1. **National and subnational public transportation electrification goals in LAC**

Country	National goals	Subnational goals
Brazil		• **Salvador:** Zero-emission bus fleet by 2035. • **Sao Pablo:** A 2018 amendment of the Sao Paulo Climate Law mandates the city to eliminate fossil fuel CO2 emissions by January 2038. The city also has an interim target of deploying 2,600 electric buses by 2024.
Chile	100% by 2050	• **Santiago:** Zero GHG emissions bus fleet by 2035
Colombia	By 2028, 100% of mass transit systems that were operating in 2018 must be operating with electric and dedicated natural gas vehicles. By 2030, at least 20% of the new fleet for Integrated Mass Transportation Systems (SITM), Strategic Public Transportation Systems (SETP), Integrated Public Transportation Systems (SITP) and Integrated Regional Transportation Systems (SITR) must be zero-emission technology.	• **Bogota:** No acquisition of fossil fuel powered public transportation vehicles from 2022 onwards. Zero-emission bus fleet by 2035.
Costa Rica	100% by 2050	
Ecuador	20%-30% by 2030 and 60%-70% by 2040	• **Cuenca:** Zero-emission bus fleet by 2035.
Jamaica	10% by 2025 and 16% by 2030	
Panama	15% - 35% by 2030	
Paraguay	10% - 20% by 2030	
Peru	35% of acquisitions by 2030	
Dominican Republic	30% by 2030 and 100% by 2050	
Several		• **Bogota, Medellin, Mexico City, Quito, Rio de Janeiro, Santiago:** C40's Green and Healthy Streets Declaration establishes that only zero-emission buses should be acquired starting on 2025.

Source: Prepared by the authors based on reviewed transportation electrification strategies and Xie & Delgado (2022).

Coupled with the prioritization of sustainable mobility in urban mobility plans, national and local governments use a variety of policy instruments to drive forward the energy transition, especially in public transportation. Chile launched its "National Electromobility Strategy" in 2017 and updated it in 2021. The Strategy incorporates major goals: by 2035, all urban public transportation vehicles entering service in cities must be zero-emission, and sales of light internal combustion vehicles will be banned, thus contributing to achieve carbon neutrality by 2050. In this context, Chile has been implementing an ambitious bus replacement plan in Santiago since 2016, which has led to a reduction in GHG emissions in the capital city. Funds for this investment were facilitated by a regulatory reform that separated ownership from operation, allowing electric power companies to invest in bus companies. Total emission reductions from the sustained incorporation of electric buses are estimated to reach more than 173,000 tonnes of carbon dioxide (Table 5.3.2). During 2023, Santiago has been incorporating the largest fleet of electric buses in its history, which is expected to reach approximately 1,900 buses (DTP, 2022) and make the city one of the world leaders in public transportation electrification.

TABLE 5.3.2. **Evolution of the number of electric buses and estimation of emission reductions in Santiago (2016- 2023)**

Year	Total electric buses	Emission reduction by incorporated buses (Tonnes CO2)
2016	1	420
2017	3	720
2018	103	30,000
2019	411	73,920
2020	784	67,140
2021	784	0
2022	809	1,500
2023	1,900	N/D*

Source: Prepared by the authors based on DTP (2019); Saka et al. (2021); Gutiérrez (2022); DTP (2022).

Note: Buses incorporated in 2023 are not in operation yet, so they are not counted for emission reductions. The emission reduction calculations were made with the assumption that each electric bus that enters the system implies the exit of a diesel bus and that, in major public transportation, the replacement of an electric bus for a diesel unit reduces 60 tonnes of CO2 per year (Ministry of Energy, 2021a).

For its part, the Government of Colombia has created different regulations and strategies that establish electrification as a central aspect of its transportation policy, especially in terms of urban mobility. As a result of this process, whose main regulation is the "National Strategy for Electric Mobility" of 2019, by February 2023 Colombia had 1,589 electric buses, most of which were in Bogotá (1,485) and the rest in Medellin (69 buses) and Cali (35 buses) (E-Bus Radar, 2023). The process of electrification of Bogota's public transportation fleet began in 2018, when Transmilenio S.A. (TMSA) decided to incorporate electric buses to renew the fleet of its first two phases (Phases I and II). From then on, successive adjustments were made for the incorporation of electric buses in the bidding processes. As in Santiago, the electric power companies have financed the electric buses. In 2021, the Bogota City Council defined actions to address the climate emergency and compliance with the city's decarbonization goals, establishing that, as of January 1, 2022, Bogota could not launch zonal or trunk public transportation contracting processes based on fossil fuel-powered vehicles, including the renewal of the fleet of Phase III contracts. In this way, Bogota managed to incorporate 1,485 electric buses and 794 Euro VI standard buses between 2019 and 2021.

5.2.2 POLICY INSTRUMENTS

Once decarbonization and adaptation to the projected CC impacts are established as policy priorities in terms of urban mobility – stipulated in the subsector plans –, the public sector must combine different policy instruments to materialize the proposed objectives in this area. To this end, it has five types of instruments at its disposal: (i) regulations; (ii) public procurement; (iii) pricing instruments; (iv) non- financial incentives; and (v) investments. For each type of instrument, the table below includes the main actions suggested according to each of these categories and their temporary implementation, both in terms of mitigating emissions from urban mobility – in the "Avoid-Shift-Improve" scheme – and in terms of adaptation to CC. The table is followed by examples of the implementation of these measures by different LAC countries.

Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
Regulations	**Avoid** • Establish incentive measures for shared mobility • Regulation on sustainable urban logistics operations (schedules and urban areas)	**Avoid** • Laws and land use plans favoring compact and multimodal cities	
	Shift • Establish measures to restrict the circulation of polluting vehicles • Prioritize actions that improve the quality of public transportation • Promote the improvement of the business structure of public transportation • Develop funding and financing mechanisms for public transportation systems (mechanisms for land value capture, fees, taxes, and contributions with specific destination) • Promote TOD measures	**Shift** • Set regulations for parking supply • Prioritize actions that improve the quality of public transportation • Promote the improvement of the business structure of public transportation • Promote TOD measures	
	Improve • Generate and openly report emissions inventory at the local level • Establish regulatory sandboxes for the testing of new fuels • Set vehicle emission standards and limits • Establish regulations on technological ascent in the automotive fleet • Enable investment schemes that involve private actors from other sectors, such as energy, in the provision of public transportation • Establish regulations for the development of charging infrastructure and business models for the promotion of clean mobility • Paratransit regulation, professionalization, and integration	**Improve** • Set an emission reduction goal for the subsector at national level • Set a goal for the replacement of polluting vehicles with units using clean or net-zero energies • Set a goal for the use of electrical energy by the vehicle fleet • Set targets for the phased reduction of carbon content in fuels • Issue safety standards for production, management, and disposal of new fuels • Review habitat protection measures against new fuels and technological development	**Improve** • 100% renewable energy used in charging stations for zero-emission fleets

Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
	Adaptation • Reevaluate design, construction, and operation and maintenance standards to reduce the impact of CC • Generate enabling conditions in the public sector that catalyze the financial sustainability of the operation and updating of monitoring and prediction systems such as those for early warning of natural hazards • Create coordination and cooperation mechanisms between the different government entities that generate climate data and information and the line ministries that use that information for intervention planning and decision-making • Establish infrastructure inspection provisions based on the gradual changes projected by CC • Review territorial planning to limit developments in risk areas or areas with key ecosystems for emission reductions and protection of socio-ecological systems to the impacts of CC (for example, recharge zones in a basin or areas with carbon sinks and biodiversity richness)		**Adaptation** • Establish freight and public transportation operations away from high-risk areas
Public procurement	**Improve** • Include zero-emission technologies in public procurement. • Evaluate business models to be included in public transportation tenders to promote zero-emission mobility	**Improve** • Formulate new tenders, and update existing ones, with energy performance parameters, use of renewable energies, new technologies, and actions to adapt to CC	**Improve** • Formulate new tenders and update concessions for public transportation and logistics services and operations according to international guidelines and national goals, as well as adaptation actions to CC
	Adaptation • Include environmental management and monitoring systems in new tenders and update concession contracts for this purpose • Include project risk analysis and CC adaptation plans in new tenders, and update concession contracts for this purpose • Reinforce maintenance works on urban transportation infrastructure according to its useful life and projected CC impacts		

Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
Price instruments	**Avoid** • Evaluate mechanisms to charge by distance traveled to replace the loss of fuel tax revenue derived from the switch to electric fleet • Evaluate road pricing mechanisms to improve traffic management in central areas		
	Shift • Evaluate carbon pricing mechanisms • Evaluate road pricing mechanisms for polluting vehicles • Evaluate taxes on the possession and use of internal combustion vehicles • Evaluate demand subsidies in public transportation • Evaluate pricing mechanisms for funding and financing the public transportation system • Evaluate tax exemptions for active mobility companies	**Shift** • Implement supply/demand subsidies for public and active transportation	
	Improve • Establish tax incentives for innovation and energy efficiency projects, including clean freight hubs and green corridors • Evaluate parking fee exemptions for zero- emission vehicles • Evaluate subsidies for electric mobility (supply and demand subsidies)	**Improve** • Establish fiscal incentives for innovation and energy efficiency projects • Subsidies for clean energy sources	
			Adaptation • Subsidies or tax cuts for adaptation measures (e.g., increasing green areas to reduce the heat island effect and improve drainage systems) • Use of insurance (e.g. insurance premiums subject to regular maintenance of existing infrastructure as an incentive to ensure adequate maintenance)

Instrument	Temporality		
	Short term (2025)	**Medium term (2030)**	**Long term (2050)**
Non- financial incentives		**Shift** • Raising awareness of the need for more sustainable mobility	
	Improve • Provide permits for the testing of new technologies to reduce emissions • Give urban access priority to energy- efficient trucks • Exemption from traffic and parking restrictions for electric vehicles • Map capacities for energy transition in the subsector • Create alliances with international cooperation to finance programs and promote the exchange of international experiences • Promote research applied to the transition and adaptation of the subsector, including nature-based solutions	**Improve** • Facilitate testing of new technologies to reduce emissions • Create a capacity building program for energy transition in the subsector • Facilitate eco-driving programs for drivers	
Investments	**Shift/Improve** • Redistribute urban space dedicated to vehicles towards public and active transportation • Investment in mobility management systems with new technologies • Investment in digital platforms that improve modal integration and logistics operation • Investment in electric buses and promotion of electromobility (e.g. charging infrastructure, electrical reinforcements) • Driver's training	**Shift** • Infrastructure for active transportation • Public transportation infrastructure (exclusive lanes, BRT, Metros, among others)	
		Improve • Investment in production chains for zero-emission vehicles • Investment in charging infrastructure for zero-emission vehicles	**Improve** • Investment in research and development of new zero-emission technologies
	Adaptation • Assess existing criteria for the selection of adaptation measures in the sector based on the benefit-cost ratio and broad participation of the most vulnerable groups in such measures • Identify public investments and adjustments of organizational functionality to be made for the implementation of adaptation actions of transportation infrastructure systems and urban logistics • Strengthen the maintenance of urban transportation infrastructure according to its useful life and projected CC changes for each region	**Adaptation** • Make the required public investments for this period to adapt transportation infrastructure and urban logistics	

BOX 5.4.

Electromobility policy in Colombia: articulation of vision, planning, and policy instruments

In Colombia, the transportation sector is the largest energy consumer (42.8%), followed by the residential (26.6%), industrial (23.4%), and tertiary (7.2%) sectors. Within the framework of the Paris Agreement and the fulfillment of the goals established in its NDC, the country has developed a set of plans, laws, and strategies to promote electric mobility (Table 5.4.1).

TABLE 5.4.1.

Regulatory framework for the development of electric mobility in Colombia

Regulation	Details
NDC Update, 2019	Identification of sectoral measures associated with electric mobility, including identification of targets and mitigation potential.
Public policy documents (CONPES)	Diagnosis of challenges and definition of actions to be developed by the different sectors, incorporating CC and the importance of the energy transition to fight against it as transversal elements, through the following documents: • Sustainable Development Goals (CONPES 3918 of 2018) • Green Growth Policy (CONPES 3934 of 2018) • Policy for the improvement of air quality (CONPES 3943 of 2018) • Policy for the Energy Transition (CONPES 4075 of 2022)
National Air Quality Strategy, 2019	Sets targets for the definition of pollutant emission measurement procedures for new and in-use vehicles available worldwide and the need to generate economic and market incentives for the reduction of pollutants from mobile and stationary sources.
Electric Mobility Strategy, 2019	Establishes an action plan for the Ministries of Energy, Environment, Transportation and Trade to develop measures aimed at overcoming the main challenges for electromobility. It focuses on four instruments: (i) regulatory and policy; (ii) economic and market; (iii) technical and technological; and (iv) infrastructure and land use planning.

National Sustainable Transportation Strategy, 2022	Establishes the objective of reducing polluting and GHG emissions, optimizing energy efficiency and modernizing the vehicle, river, maritime and rolling stock fleet of the transportation sector, through the prioritization of the use of zero- and low-emission technologies, guiding transportation towards carbon neutrality.
Law No. 1964 of 2019 on Electric Mobility	Aims to generate schemes to promote the use of electric and zero-emission vehicles, contributing to sustainable mobility and the reduction of polluting and GHG emissions.
Law No. 1972 of 2019 on Air Quality	Establishes measures for the reduction of air pollutant emissions from mobile sources circulating throughout the national territory, with emphasis on particulate matter.
National Development Plan 2018-2022	Sets electric vehicle goals.

Source: Prepared by the authors based on Government of Colombia (2019c, 2019b, 2019a, 2020, 2022) and DNP (2018a, 2018b, 2018c, 2019, 2022).

Support for the deployment of electric mobility has included the development of incentives for the purchase of electric vehicles. These include preferential use of parking spaces; exemption from vehicle circulation restriction measures; setting maximum rates for the motor vehicle tax (lower than those applicable to internal combustion vehicles); discounts on mandatory insurance premiums and technical-mechanical inspections; and exemption from payment of the contribution on the energy bill. Likewise, different forms of financing are being used for the transition to the electric fleet, including the possibility of co-financing from the Nation for the acquisition of new low- or zero- emission fleets; implementation of additional financing sources by the municipalities; complementary activities for the use or economic exploitation of the transportation infrastructure; visual advertising inside and outside the infrastructure and vehicles of the transportation systems; development of urban projects in the areas acquired for the implementation of the transportation systems; and co-financing up to fifty percent (50%) for public transportation systems that are in operation. In addition, the following are being developed: (i) the "District Fund for the Promotion of Technological Upgrading of Urban Freight in the Capital District"; and (ii) the "Fund for the Promotion of Technological Upgrading of Transportation Systems, Freight Vehicles under 10.5 tonnes, and Taxis". These two instruments seek to facilitate the financing of zero and low-emission transportation projects, plans and programs, granting reimbursable and non-reimbursable incentives to municipalities and private owners.

BOX 5.5.

Guatemala: Use of a pilot to define biofuel regulations and estimate the potential for CO2 emission reductions in the transportation sector

In order to reduce CO2 emissions from the transportation sector, the authorities in Guatemala developed a "Green Mobility Pilot" during 2020 to test the efficiency of gasoline with advanced and certified ethanol (ecopower). They evaluated 34 vehicles for 10 weeks, using 5% ethanol blends during the first five weeks and 10% blends during the last five weeks. The pilot results showed the following reduction in combustion gases: hydrocarbons up to 74.17 %; CO up to 71.74 %; SO2 up to 54.18 %; NO up to 39.96 %; and CO2 up to 21.17 %. The oxygen content in ethanol results in combustion improvements, reducing CO2 emissions. Regarding the use of ecopower E10, an average reduction of 71.7% was achieved compared to gasoline without ethanol.

As a result of this exercise, ethanol is promoted as a renewable fuel in Guatemala, with an approximate production of 65 million gallons of ethanol per year. The Ministry of Energy and Mines is developing a regulation law that will come into force in January 2024, to blend 10% ethanol with gasoline and distribute it in the country's gas stations (MEM, 2022). This would entail benefits in terms of reducing emissions from the transportation sector by more than 218,750 tonCO2eq/year.

BOX 5.6.

Public bicycle sharing systems in LAC

Public bicycle sharing systems, also known as bike sharing systems or bike rental systems, are gaining popularity in the region due to the benefits of bicycles for health, mobility, and carbon footprint reduction of cities. By the end of 2019 there were 92 public bicycle sharing systems in the region, mostly located in Brazil (42 systems), Colombia (18 systems) and Mexico (15 systems), in cities above one million inhabitants (LatinoSBP, 2019). The main bike-sharing systems in the region include "Ecobici" in Mexico City, "Mibici" in Guadalajara, "Bike Santiago" in Santiago de Chile, "Bike Rio" in Rio de Janeiro, "Bike Sampa" in Sao Paulo and "EnCicla" in Medellin.

The dimensions of public bicycle sharing systems are determined by the number of bicycles and stations. In Mexico City, "Ecobici" has 9,300 bicycles and 687 stations (Ecobici, 2023). Rio's bicycle system, "Bike Rio", which was the first public bicycle sharing system in the region, originally under the name "SAMBA", already has 3,600 bicycles and 355 stations (Bikeitau, 2023b). In Santiago, the bicycle system consists of 3,500 bicycles and 230 stations (Bikeitau, 2023a). in Medellin, "EnCicla" had 2,000 bicycles and 103 stations in 2021 (Valle de Aburrá Metropolitan Area, 2021). These mobility systems have expanded over the years in response to growing demand and uptake.

5.2.3 INSTITUTIONAL FRAMEWORK

The design of plans and policies for decarbonization and resilience of urban mobility must be accompanied by institutional strengthening. The experience of benchmark countries shows that specialized teams are required for the design, implementation, monitoring, and evaluation of the effectiveness of policy actions in this area. This strengthening should be carried out in the short term, in order to have governing bodies capable of designing and executing measures efficiently and effectively. Also, since urban transportation depends to a large extent on action at the local level, vertical collaboration is essential in order to ensure policy coherence. Suggested actions in this area are listed in the table below.

Level	Short term (2025)
Strengthening the capacities of public institutions that are responsible for urban transportation	• Create urban transportation authorities where there are none, given that they are the key institutions to promote sustainable mobility • Create strategic transportation authorities at the metropolitan level with governance powers, including resource availability, decision-making capacity, and capacity for infrastructure construction and operation • Establish, within the governing body in charge of urban mobility, a permanent unit/group in charge of the elaboration, implementation, monitoring and updating of the strategy and programs related to CC, and the inclusion of public transportation and active mobility in the NDCs, with actions that are applicable to the local context • Require the generation, systematization, and analysis of information on emissions and risks of CC, in order to influence the planning and decision-making processes in the sector • Leverage technological change in the subsector and institutional digital transformation strategies and programs not only to generate information, but also to reduce emissions through digitalization (e.g. MaaS - Mobility as a Service, IoT platforms, electric vehicle booking applications) • Promote the implementation of pilots to test decarbonization and climate resilience solutions as part of the management of urban infrastructure and transportation services and in related processes. In this context, seek alliances with the private sector and academia for the access and implementation of solutions and the evaluation of their benefits and challenges • Promote the exchange of experiences between cities, to create practice communities at regional, national, or international scales in the mainstreaming of actions to mitigate GHG and adapt to the impacts of CC • Adapt the public procurement policies carried out by these entities to include emission reduction and climate resilience criteria • Develop training programs aimed at including CC adaptation considerations in the processes, tools and infrastructure projects developed by urban transportation agencies
Horizontal coordination	• Coordinate transportation and land use plans in order to reduce travel needs and promote the use of public transportation and active modes, and promote close collaboration between local entities with mobility and urban planning prerogatives • Ensure that committees related with urban transportation include representatives from other transportation modes, energy, environment, industry and commerce, logistics, among others, and have clear competencies to act on mobility sustainability • Seek to incorporate urban transportation subsector representatives in committees constituted for other topics, but whose decisions are key to implement actions for the subsector's sustainability, such as those related to the promotion of electrification, biofuels, and public health
Vertical coordination	• Require, from the national government, the development of sustainable urban mobility plans in line with nationally defined principles, and link the provision of funding and financing to the availability of these plans

- Generate programs at the national level that support urban mobility planning through guidance materials, peer learning, training programs, exchange of experiences and financial support
- Develop institutional mechanisms for metropolitan coordination, for example through committees, to ensure effective coordination between different levels of government and favor infrastructure investment planning and regulation of transportation services. Establish these committees within the strategies and master plans for the subsector, and have the highest subsector authority attend these meetings to reinforce their role
- Develop coordination mechanisms between the national and local levels to design and implement actions aimed at meeting the urban mobility goals set out in the NDCs
- Include the Ministries of Transportation in the processes of defining goals and implementing actions
- Coordinate the responsibilities of metropolitan authorities with the national and local levels, ensuring that they are aligned with the National Urban Mobility Policies and Programs (NUMP) and Sustainable Urban Mobility Plans (SUMP)

5.2.4 STRATEGIC ALLIANCES

Given the magnitude of required investments in sustainable urban transportation and the increasing pressure on public finances, mobilizing private investment has become a necessity. Governments have a key role to play in influencing private sector investment by establishing a regulatory framework and creating incentives for sustainable investments in transportation infrastructure and services. Transportation management models are multiple: private operators, public operators, service contracts, public-private partnerships, full privatization with public regulation that can be more or less. Paratransit should also be considered. Private companies must be integrated in the design and implementation of policies, as well as encouraged to innovate and promote digital solutions in transportation services. For its part, academia plays an important role in the production of prospective studies, applied research, innovation, talent training and policy evaluation. This is how all benchmark countries have established strong collaboration ties with both sectors. The following are suggested actions to forge and strengthen alliances with strategic actors for urban mobility.

Temporality	Action
Short term (2025)	• Form permanent working groups with representatives of manufacturers, operators, public transportation companies, active transportation companies, energy companies, and others related to urban operations, in order to agree on sustainability strategies and actions at the national and city level • Enable interoperability of transportation systems through coordination between operators and data sharing • Establish memoranda of understanding or cooperation with the private sector and academia to promote pilots and technology deployments for decarbonization and inclusion of NBS in transportation infrastructure design • Identify gaps in human talent and design training programs together with the private sector and academia • Generate alliances with local and international financial systems to channel resources to facilitate the public transportation fleet conversion (example in Box 5.8)
Medium term (2030)	• Promote research and development of technological solutions with the private sector and academia

BOX 5.7.

Promoting public transportation electrification in Bogota

TMSA is a private company owned by the District of Bogota that administers and manages the city's mass transit system. As of June 2022, it had a fleet of more than 10,693 buses transporting more than 1.6 million passengers per day. In 2019, TMSA launched public tenders to concession the provision and operation and maintenance of electric buses. To support this stage of electric mobility expansion in Bogota, IDB Invest acted as lead arranger of financing for 401 low-emission electric buses and the construction of associated charging infrastructure along 10 transportation routes concessioned by TMSA in the localities of Fontibón and Usme. The financial package for the project – under conditions adapted to the business model and mobilizing local and international liquidity sources – consisted of two senior loans granted to two special-purpose vehicles (one for the Fontibón concession and the other for the Usme concession)

Generating alliances with the financial sectoris key for the energy transition.

created by ENEL X, a business line of Enel Colombia for electric mobility projects, and InfraBridge, a global infrastructure investment fund dedicated to investing in medium -sized companies in transportation and logistics, digital infrastructure, and energy transition. The loans granted by IDB Invest, the United Kingdom Sustainable Infrastructure Program (UKSIP) and BNP Paribas exceed 610 billion Colombian pesos (approximately USD 134 million) and have a term of up to 14.5 years.

The financing includes favorable terms for the project's characteristics, such as tailor-made term and amortization profiles. UKSIP's concessional financing resources, managed by IDB Invest, complement scarce resources in the market and improve the amortization profile charged towards the end of the concession, assuming part of the exposure risk during the last years of the loan. This long-term financing allows the sponsors to balance the debt structure of the project and reinvest the capital in other projects in the region. In addition, IDB Invest has provided technical assistance to maximize the efficiency of the bus batteries during operation and develop a plan to reuse the batteries once they are replaced in the eighth year of operation. The expected impact of this project is a reduction of 237,464 tonnes of CO_2 emissions, 3.10 tonnes of PM2.5 emissions, and 4,663 tonnes of NOx emissions by 2037. In addition to the environmental benefits, the introduction of the new buses will contribute to improve the transportation service, as they are equipped with features such as WIFI, USB ports, handicapped access, GPS, and assistance for driving on slopes.

5.3.
Roadmap for the decarbonization and resilience of road transportation

In LAC, consideration of CC mitigation in the road transportation sector is incipient, in contrast to the experience at the international level. The road sector in general, and freight transportation in particular, have received little attention in the NDCs, with some exceptions. The case of Colombia stands out with the consideration of logistics optimization, the mode shift from road to river transportation on the Magdalena River and the modernization program for automotive freight transportation proposed in its NDC (Government of Colombia, 2020). On the other hand, with respect to planning, the use of tools such as LCA – to compare different alternatives from an environmental perspective – is not incorporated in the procedures of road authorities in the region. In addition, the prioritization of the issue and the availability of instruments to encourage decarbonization and climate resilience is scarce, although the trend is changing. In this sense, for example, Argentina's National Transport Action Plan includes different mitigation actions within the axis of freight transportation intervention (Presidency of the Nation, 2017). For its part, Mexico is implementing the "Sustainable Transport Financing Program" with the aim of reducing emissions, providing credits to the micro, small and medium-sized enterprises (MSMEs) sector for the renewal of the vehicle fleet of freight transportation and urban passenger transportation (Secretariat of the Treasury and Public Credit, 2022).

The high atomization of operators and informality of land freight transportation requires special instruments to advance in the decarbonization of the sector. It is estimated that in most countries of the region, 99% of operators are freight transportation MSMEs (Calatayud & Montes, 2021). Between 20% and 40% of operations are carried out informally (Barbero et al., 2020). In addition, there is evidence of low occupancy and utilization (distance traveled) of the fleet (Calatayud & Montes, 2021). The size of the companies, together with the high level of informality and the type of service provided, generate productivity and financial conditions that make it difficult or impossible for transportation operators to access technologies and renew fleets through traditional instruments. This, together with the degree of maturity of technology in the sector, has resulted in a very low penetration of more energy-efficient vehicles. In fact, the average age of the fleet in the region is between 14 and 17 years old, compared to 11.7 years in the EU, for example, to the detriment of greater energy efficiency in the subsector (Barbero et al. 2020).

The development of instruments facilitating the mainstreaming of climate resilience and adaptation in planning and decision-making processes is not yet widespread in the subsector. This refers both to the functional vulnerability of transportation networks and to the structural vulnerability of the different links in the network. Some countries in the region have studies focused on characterizing risk and generating recommendations to support decision-making involving CC resilience and adaptation criteria (Box 5.8). Nevertheless, there are wide gaps to overcome in order to incorporate adaptation holistically and systematically in road transportation. Few countries in the region have advanced with specific sectoral plans or documents for road transportation adaptation. Among those who did, Mexico stands out with CC adaptation procedures for its rural and feeder roads (2022), and Colombia with the publication of "Roads – CC Plan: roads compatible with the climate" (2014), the "Climate Risk Study for the Primary Road Network" (2015) and the "Green Road Infrastructure Guidelines" (2020). In contrast, international experience shows significant progress in the incorporation of CC adaptation in the subsector, both at the planning level and in the implementation of adaptation measures.

There are two speeds in the incorporation of Environmental, Social and Governance (ESG) criteria in road projects. In the private sector, some of the main construction firms have begun to incorporate concrete ESG actions in the development of their projects. However, the public sector has not developed a regulatory framework to promote the widespread adoption of these criteria by all private actors involved in the design, construction, operation, and maintenance of road infrastructure. Nor is there often a specific allocation of funds for the adaptation of road transportation to CC. Furthermore, the specific allocation of funds for the adaptation of road transportation to CC is not common in countries of the region

In this context, LAC countries require a roadmap for the sector's decarbonization and adaptation that, leveraging international best practices, is consistent with the particular traits of the region and maximizes its potential to contribute to sustainability. As in the previous section, the suggested policy actions for the road mode are presented below, organized into the four categories used in this chapter: (i) strategic vision; (ii) policy instruments; (iii) institutional framework; and (iv) strategic alliances. Additionally, to provide a time horizon for implementation, they are classified into short, medium and long term.

5.3.1 STRATEGIC VISION

The roadmap should start by identifying decarbonization and climate resilience as public policy priorities for road transportation. This should be reflected in the transportation plan and existing plans or strategies at the subsectoral level. It is crucial that this action is carried out in the short term, since such prioritization will facilitate the implementation of policy instruments (see subsection 5.3.2) to advance decarbonization and CC resilience. At the institutional level, this prioritization of decarbonization and resilience within the strategic vision for road transportation should be generated by the competent authority for road transportation planning, with the participation of the ministries of energy, environment, and agencies related to the road-logistics subsector. Road or highway plans, prepared by the corresponding road agencies, should be carried out and/or reformulated in accordance with the guidelines for this vision. The table below includes suggested actions to achieve this prioritization, based on the best practices identified in Chapter 4.

Temporality	Action
Short term (2025)	• Prepare prospective studies on the opportunities and impacts of the subsector decarbonization in terms of efficiency, competitiveness, NBS and ecosystem services including biodiversity, which identify scenarios, opportunities, barriers and lines of action for public policy, serving as input for plans and strategies • Identify CC risks on infrastructure and road operations and services • Consult with actors from the road sector, logistics sector, energy sector, academia, public agencies, civil society and other stakeholders, with a view to incorporating CC into sectoral and subsectoral plans • Modify the transportation sector plan and the highway or road subsectoral plan to recognize the importance of CC and its impacts, setting the vision for the future and the main lines of action around CC monitoring and management, energy sources, intermodality, coordination with other sectors, etc. • Develop a CC action plan for the subsector that, based on prior analysis and consultations, establishes a roadmap with concrete measures to promote decarbonization and adaptation (see instruments subsection)
Medium term (2030)	• Establish emission reduction targets for the subsector, consistent with international regulations

BOX 5.8.

Analyzing LAC's road network resilience

Although much less widespread than in benchmark countries, there are studies in the region that analyze road network resilience to CC. For example, the IDB-supported study for Ecuador ranked the country's road network according to sociodemographic criteria, road characteristics, critical infrastructure, and economic importance, issuing recommendations to improve the network's climate resilience. These include the creation of early warning systems; updating national regulations to incorporate risk management criteria; investments in preventive maintenance; and the implementation of NBSs to boost resilience (AECOM, 2019). Similarly, the Dominican Republic has conducted a risk analysis for the road network, considering historical geophysical and hydrometeorological hazards and the influence of CC on them, and developing a methodology to select the most appropriate adaptation measures to be implemented in each case (Deltares, 2020; Olaya González et al., 2022).

Colombia and Brazil also have similar studies, which identify high-risk road sections and establish measures to be implemented by sector entities to ensure resilience. For example, Colombia developed a similar analysis in "Roads – CC Plan: climate compatible roads", which also enabled creation of a CC group within the Ministry of Transportation to manage the plan's implementation and updating.

5.3.2 POLICY INSTRUMENTS

To materialize the priority of decarbonizing and adapting road transportation to CC, the public sector has five types of instruments at its disposal: (i) regulations; (ii) public procurement; (iii) pricing instruments; (iv) non-financial incentives; and (v) investments. Given the uncertainty surrounding the magnitude and evolution of CC scenarios, it will be key to adopt a flexible approach whereby instruments are chosen and calibrated according to the mitigation and adaptation pathways established at the international and national levels. These pathways allow short- and medium-term measures adopted in the sector to be consistent with long-term objectives, providing flexibility to adjust such measures as CC scenarios materialize or change, in a context of uncertainty. The following table includes suggested actions in the short, medium, and long term, for each type of instrument. The table is followed by examples from the region where actions such as those suggested here are already being implemented.

Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
Regulations	• Generate and openly report an emissions inventory for the subsector and integrate it with the subsector's information systems • Regulate the quality and types of fuels • Establish/update emission standards by vehicle type • Review used vehicle import regulations to align with emission mitigation goals • Establish restrictions on the manufacture, assembly, and import of trucks with high emission standards • Establish emissions certification, auditing, and labeling programs for trucks, truck fleets, and trucking companies • Reengineer administrative processes and regulatory requirements to improve logistics efficiency • Re-evaluate infrastructure design and construction standards to reduce the impact of CC • Establish guidelines for agencies to develop climate risk monitoring and early warning systems, and to implement mechanisms facilitating cooperation and coordination among agencies responsible for planning and decision-making on climate risk management • Establish infrastructure inspection provisions • Establish/amend legislation related to emergency response • Review territorial planning to limit developments in risk areas • Develop regulatory framework for road life cycle assessments • Require mapping of risks and/or vulnerability to CC of transportation infrastructure at the subnational level, at a scale that is useful for prioritizing investments in critical and exposed infrastructure	• Set emission reduction goals for the subsector at the national level (infrastructure and vehicles) • Set a goal for the replacement of equipment and vehicles by those using clean or net-zero energy • Update standards and set emission limits by vehicle type • Update regulations on the quality and types of fuels • Establish mandatory emission reduction plans for companies with their own fleets or those hiring outsourced fleets • Implement road infrastructure charging measures • Set targets for the construction of charging stations for zero- emission vehicles	• 100% renewable energy used in logistics terminals • Relocate operations away from high-risk areas

Public procurement	• Include environmental management and monitoring systems in new tenders and update concession contracts for this purpose • Include risk analysis in new tenders for CC adaptation projects and plans (according to adaptation pathways), and update concession contracts for this purpose • Include eco-driving requirements in tenders • Reinforce maintenance works within road concessions • Consider setting emission reduction targets • Consider bonus and penalty systems to reduce road sector emissions • Incorporate pilots in contracts for the implementation and evaluation of new materials and technologies that catalyze emission mitigation and adaptation to CC • Implement road life cycle assessment	• Formulate new tenders and update road concessions with parameters of energy performance, use of renewable energies and adaptation actions to CC according to adaptation pathways, both in infrastructure and services • Require the participation of experts in CC adaptation in design and construction contracts • Clearly establish the distribution of risks between the public and private sector in the face of extreme weather conditions • Use performance-based contracts that include climate resilience targets and indicators	• Conduct new tenders and update road concessions according to international guidelines and national goals, as well as adaptation pathways to CC • Create new contracts to ensure that all infrastructure is resilient, including critical infrastructure such as tunnels and bridges
Pricing instruments	• Establish tax incentives for innovation and energy efficiency projects in logistics • Establish programs that promote energy efficiency through the scrapping and renewal of land transportation fleets • Consider the implementation of pricing instruments for emission reductions (GHG emission prices, fuel tax and emission rights regime for road transportation) • Consider the implementation of vehicle taxes (differentiated by CO2) and incentives for the purchase of zero-emission vehicles	• Establish tax incentives for projects of innovation and energy efficiency in logistics • Scale up scrapping and renewal programs for transportation fleets, with a focus on zero- emission vehicles • Consider the implementation of road infrastructure pricing (smart pricing, differentiated by CO2)	• Ubiquity of smart road pricing

Non-financial incentives	• Facilitate permits for testing of new technologies to reduce emissions • Map capacities for energy transition in the subsector • Create alliances with international cooperation to finance programs and promote the exchange of international experiences • Encourage research applied to the transition and adaptation of the subsector, including NBS • Implement vehicle labeling (including fuel efficiency and CO2 emissions) • Develop business capacity building programs for freight transportation, including sustainability aspects • Develop eco-driving and related certification programs	• Facilitate testing of new technologies to reduce emissions • Create a capacity- building program for energy transition and adaptation in the subsector, including capacities to analyze the physical and economic benefits of investments in NBS and the promotion of biodiversity in an integrated way	
Investments	• Prioritize public investments to be made for the adaptation of road infrastructure based on risk estimates • Strengthen the maintenance of road infrastructure including bridges, tunnels and drainage works • Implement Intelligent Transportation and ICT Systems for infrastructure management, maximizing capacity and durability, and fleet management for improved efficiency • Implement early warning systems for emergencies • Develop clean public fuel refueling infrastructure that enables long- distance transportation	• Make the public investments required in this period to adapt the road infrastructure • Develop public charging infrastructure that allows long-distance transportation	• Make the public investments required in this period to adapt the road infrastructure

BOX 5.9.

Incorporating resilience in transportation Public-Private Partnerships (PPPs) in Colombia

The IDB and the National Infrastructure Agency (ANI, after its Spanish initials) have developed a Toolbox for the preparation of CC-resilient PPP projects that provides decision-making tools for each phase of their life cycle. In the Initial Assessment stage, a high-level assessment of climate risks and their effects is performed, with the goal of preventing and/or making modifications to the project concept at an early stage. The Structuring stage includes a technical, financial, economic, environmental, social and land acquisition feasibility evaluation, incorporating climate risks and uncertainty with a comprehensive assessment of climate events identified as "severe" or "tolerable" and an estimation of costs to implement climate resilience measures. In the Transaction stage, which comprises the firm selection process and financial closure of the project, climate resilience considerations are included in the contract design, bidder qualification, project bidding and evaluation of received bids. Lastly, in the Contract Management stage, the private counterpart must ensure that the guidelines agreed upon in the contract are met and that changes in the climate risk profile receive an efficient and adequate response.

FIGURE 5.9.1. Tools for each phase of the PPP project cycle

1 Initial Evaluation

Tools provide orientation for the initial evaluation of the project exposure to CC risks

Tools - Initial Evaluation of Climate Risks

1.1. Initial evaluation of risk exposure

1.2. Initial evaluation of project vulnerability

1.3. Initial evaluation of general risk profile

2 Structuring

Integrating climate resilience objectives in the business case of a project

Tools - Analysis of Climate Risks

2.1. Exhaustive evaluation of risk exposure

2.2. Exhaustive evaluation of project vulnerability

2.3. Exhaustive evaluation of general risk profile

Tools - Risk Assessment

2.4. Incorporating climate resilience in cost estimations

2.5. Risk assessment methods

Tools - Analysis of Climate Risks

2.6. Cost-benefit analysis

2.7. Financial feasibility

2.8. Value for money

2.9. Environmental impact assessment

3 Transaction

Qualify and incentivize bidders based on a climate approach

Tools - Transaction

3.1. Include climate resilience in the invitation to pre-qualify

3.2. Decision framework to include climate resilience in the PPP request for proposals

3.3. Including climate resilience in the PPP evaluation

3.4. Including climate resilience in the performance, quality, and service level indicators

3.5. Compliance with climate resilience through availability payments

3.6. Considerations from the Disaster Risk Management Plan

3.7. Writing example regarding the requirement to periodically update the climate risks mitigation plan

4 Contract Management

Reflect about the definition of Force majeure, non-insurable, and contracts flexibility in the face of climate change

Tools - Contract Management

4.1. Contract modifications

4.2. Force majeure

4.3. Non-insurable

Source: Rebel (2022).

BOX 5.10.

Eco-driving initiatives in the region

"*Giro Limpio*" is a program funded by Chile's Ministry of Energy that seeks to reduce fuel consumption and emissions related to freight transportation. Trucking companies can voluntarily enroll in this program, which helps them monitor fuel consumption and emissions per unit of transported tonne-km and lower these values through various strategies, including eco-driving. The initiative grants certification to trucking companies that adhere to the program and to logistics operators and freight-generating companies that choose certified trucking companies. Emission reduction strategies include training eco-driving practices through the SmartDriver Chile course, which is an adaptation of the SmartDriver course originally developed by Natural Resources Canada. The program manages to attract key private sector actors thanks to the expected fuel savings, but also because of the recognition provided by the certification as companies committed to reducing emissions. The initiative plans to have 10% of the national truck fleet associated by the beginning of 2024 (Energy Sustainability Agency, 2022).

The "*Transporte Limpio*" program promoted by Mexico's Ministry of the Environment and Natural Resources is a fuel consumption reduction initiative very similar to those existing in Chile. Transportation companies and freight generators can join the program on a voluntary basis to commit to implementing fuel-saving measures, including eco-driving practices, and benefit from fuel savings, awareness of the environmental impact of their operations, and improvements in their image by being committed to the environment. The program has 718 affiliated companies and in 2021 avoided the emission of 2.7 MtCO2 (Secretariat of the Environment and Natural Resources, 2022). Additionally, the National Commission for the Efficient Use of Energy (CONUEE, after its Spanish initials) offers eco- driving courses that are optional for private fleets and mandatory for drivers who drive government agency fleet vehicles. About 40,000 vehicles that are driven by government agencies must comply with this requirement (Pineda & Xie, 2021).

BOX 5.11.

Innovation in pavement

The use of recycled asphalt in road construction and rehabilitation is a technique that takes advantage of materials from pavements that have reached the end of their useful life. The benefit of using recycled asphalt pavement (RAP) lies in the reduced use of virgin materials and the reduced need for transportation and disposal of materials, resulting in economic savings and reduced environmental impacts. This recycling technique was developed in the 1970s and is currently the most common technique for pavement construction in the United States. In LAC, there are some countries where RAP is used in pavement construction and rehabilitation. Generally, this material is used in the stabilization of base layers and not so much in the production of hot asphalt mixes, which would be the ideal use because the final quality of the mix could be equal to that of a mix produced with virgin materials. In Colombia, there are national and local regulations governing the use of this material. Brazil has used RAP in pavement construction for more than three decades, recovering millions of square meters of pavement. The State of Sao Paulo uses this technique frequently, having rehabilitated thousands of km of pavements by in situ cold recycling with Portland cement (Fedrigo et al., 2020).

Another technique that seeks to reduce the carbon footprint of road infrastructure construction processes uses rubber powder from end-of-life tires (ELTs) as an additive in asphalt mixtures. This technique improves the mechanical properties of pavements, reduces the demand for virgin materials and makes it possible to use rubber from tires that would otherwise be discarded. In LAC, this technology has been promoted through the development of test segments, its inclusion in regulations, and its incorporation in tenders. For example, in Colombia, the National Roads Institute awarded higher scores in the bids for the third round of 4G highways to proposals that included the use of asphalt rubber. Brazil has federal and local specifications for the use of ELTs in pavements, having paved a large number of roads with ELTs in several states, including the states of Rio de Janeiro, Sao Paulo and Santa

Catarina. In Chile, the specifications for hot asphalt mixtures modified with rubber powder are found in section 5.420 of the Highway Manual, and some test sections have been built to validate the properties of pavements built with this material.

BOX 5.12.

The importance of proper road asset management

The proper performance of road infrastructure depends to a large extent on the maintenance and rehabilitation investments made on the system, as lack of maintenance contributes to the accelerated deterioration of roads and can result in increases of up to 50% in future maintenance costs (Hallegatte et al., 2019). In a CC context, performing timely maintenance and having up-to-date network information becomes even more important. The projected increase in the frequency of extreme temperature and precipitation events will place growing pressure on the region's road infrastructure, and will require increasing the frequency of maintenance to minimize the cumulative impact of more frequent flooding, landslides, and damage to road surfaces. Having an infrastructure management system that provides information on the state of deterioration of assets and developing monitoring mechanisms will make it possible to identify the most at-risk and critical segments of the system. This is key not only to be able to size investment needs and plan required interventions in advance, but also to be able to provide a faster response to emergencies that considers the system's vulnerabilities (OECD, 2021).

5.3.3 INSTITUTIONAL FRAMEWORK

In order to develop and implement the above-mentioned instruments, the institutions that govern the subsector – ministries of transportation and road agencies – must be strengthened. Furthermore, given that mitigating and adapting road transportation to CC requires actions that lie outside the transportation entities, it is essential to strengthen inter-institutional collaboration so that the adopted measures are agreed upon and evaluated with sectors such as energy, environment, trade and industry. To this end, the table below suggests actions to strengthen the institutional framework. All these actions should be carried out in the short term to have governing bodies capable of developing and implementing measures, incorporating the perspective of other agencies and coordinating actions required in different areas of public policy, both national and international.

Level	Short term (2025)
Strengthening the capacities of public institutions with responsibility over road transportation	• Establish apermanent unit/group in charge of the elaboration, implementation, monitoring, and updating of CC-related strategy and programs within the governing body at the national level • Require the generation, systematization, and analysis of information on emissions and risks of CC, in order to influence planning and decision-making processes in the sector • Leverage technological change in the subsector and institutional digital transformation strategies and programs not only to generate information, but also to reduce emissions through digitalization (e.g. fleet management systems, life cycle assessment for roads, early warning systems and emergencies) and improve the climate resilience of the network and its most critical components • Promote pilots for testing decarbonization and climate resilience solutions in the management of transportation infrastructure and services and in related processes. In this context, seek alliances with the private sector and academia for the access and implementation of solutions and the evaluation of their benefits and challenges. • Adapt public procurement policies carried out by these entities to include emission reduction and climate resilience criteria • Develop training programs aimed at including CC adaptation considerations in the processes, tools and infrastructure projects developed by road transportation agencies

Horizontal coordination	• Ensure that the committees related to road transportation (led by the highest authority of the executive branch in the subsector), have representatives from other modes of transportation, energy, environment, industry and commerce, among others, and have competence over CC and the sustainability of road transportation • Seek to incorporate road subsector representatives in to committees constituted for other purposes but whose decisions are key to implementing sustainability actions of the subsector. For example, those related to promoting green hydrogen, biofuels, NBS, and ecosystem services
Vertical coordination	• Given the spatial nature of road transportation, which affects multiple jurisdictions, the departmental and municipal levels should participate in the aforementioned committees, in order to try to coordinate actions aimed at the sustainability of the subsector. Establishing these committees within the strategies and master plans for the subsector, as well as having the highest subsectoral authority in their meetings, reinforces their role • Develop coordination mechanisms between the national and local levels to design and implement actions aimed at road transportation goals set out in the NDCs

BOX 5.13.

DMDU Guide for Transportation Planning under a Changing Climate

Given the high uncertainty of climate projections and the difficulty of characterizing the risks associated with CC using fixed assumptions, the Decision Making Under Deep Uncertainty (DMDU) approach can be a useful tool for sectoral planning. This approach starts by calculating risks for a set of climate projections or risk probability distributions, yielding a wide range of possible futures. It then proceeds to identify which components of the transportation infrastructure contribute most to risk under the full range of scenarios and which strategies can reduce risk for that wide range of possible futures. Rather than making explicit predictions about which future scenario might occur, this approach seeks to reach consensus on actions that could potentially minimize risks and maximize benefits across the set of scenarios. The IDB developed a DMDU guide for transportation planning in a CC scenario, with three steps: (i) scenario planning; (ii) adaptive pathways and flexible design; and (iii) robust decision- making (Lempert et al., 2021). This guide has been implemented in countries such as the Dominican Republic and Haiti, and in IDB-supported road projects throughout the region. In addition, within the wide range of decision support approaches, there are other complementary methods to DMDU, such as the Info Gap Theory and the Dynamic Adaptation Policy Pathways (DAPP). The latter is based on the concept of adaptation tipping points and seeks to establish the sequencing of adaptation measures based on the change of these points. It is used in different latitudes, both by national and local organizations, as well as internationally in projects financed by them.

5.3.4 STRATEGIC ALLIANCES

Since road transportation is fundamentally a private business, integrating the sector's companies in the dialogue and design of policy actions is crucial and urgent. The use of collaborative platforms that bring together industry leaders with public policy makers and other relevant stakeholders can be a strategy to combine efforts, resources, knowledge, and best practices to jointly address the challenges of road transportation decarbonization, accelerating the development and adoption of sustainable solutions. For its part, academia plays an important role in the production of prospective studies, applied research, innovation, talent training, and policy evaluation. Thus, all benchmark countries have established strong collaborative ties with the private sector and academia. Based on these experiences (see Chapter 4), the following table suggests actions to establish strategic alliances with the private and academic sectors.

Temporality	Action
Short term (2025)	• Form permanent workgroups with representatives of logistics operators, road concessionaires, energy companies, freight providers, land transportation companies and others related to road operations, in order to agree on sustainability strategies and actions at the national level • Establish memoranda of understanding or cooperation with the private sector and academia to promote pilots and technological deployments for decarbonization • Identify gaps in human talent and design training programs together with the private sector and academia

BOX 5.14.

International coalitions for road transportation decarbonization

Leading companies in the global road freight sector, including ALC, have implemented a number of strategies to reduce emissions and transition to more sustainable operations. These strategies encompass early adoption of zero- emission vehicle fleets, investment in renewable energy sources to power vehicles and infrastructure, and implementation of efficient logistics and route optimization to minimize fuel consumption and mileage. Despite value chain commitments, decarbonization of road freight transportation cannot be achieved by the private sector alone, especially due to the lack of charging and refueling infrastructure, regulatory gaps, and lack of funding. Thus, strong collaboration between public and private entities is required. This collaboration involves policy makers, industry stakeholders and financial institutions working together to develop supportive policies, provide financing mechanisms, and facilitate the deployment of the necessary infrastructure for zero-emission vehicles.

By aligning objectives and sharing experience, resources and knowledge, significant progress can be made towards achieving a sustainable and decarbonized road freight sector. International platforms such as the World Economic Forum's First Movers Coalition and Road Freight Zero play a crucial role in fostering this collaboration (WEF, 2021c). They provide opportunities for industry leaders, policy makers and experts to meet, share best practices, replicate successful initiatives across borders, and leverage resources. This collaborative approach has led to notable examples that can be replicated in LAC, such as Holcim's commitment within the First Movers Coalition to deploy up to 1,000 Volvo electric trucks by 2030 in Europe, showing the potential for large-scale adoption of electric trucks by a major industry player. In addition, partnerships are emerging such as Milence, a joint venture of Daimler Truck, Traton Group and Volvo Group, to address the infrastructure deficit, with plans to launch a large-scale public charging network for heavy trucks across Europe.

5.4.
Roadmap for the decarbonization and resilience of maritime transportation

In the region, awareness of the urgency of promoting greater sustainability in maritime transportation is low in comparison with world leaders. As a result, there are few cases where the issue is included in transportation plans and even in maritime-port plans. There are practically no emission inventories at the port level, nor are there any strategies or instruments to encourage sustainability. Innovative experiences are limited to a few ports in the region that aim to improve their energy efficiency and use cleaner energies, or to a few countries that are aiming to develop new fuels as a business opportunity (Box 5.15).

BOX 5.15.

Progress in the region to decarbonize maritime transportation

The Panama Canal Authority leads sustainability initiatives in the region. Its strategy has three lines of action: (i) reduction of emissions in operations; (ii) environmental management improvements; and (iii) incentives to reduce emissions for Canal customers. The goal is to become carbon neutral in its operations by 2030. Thus, the Canal has a program to measure its GHG emissions, has implemented pilots with electric vehicles, plans to use ships with alternative fuels and a greater proportion of photovoltaic energy for operations, and has established a Maritime Single Window. This window allows it to digitize and coordinate operations with Canal users, saving more than 300,000 printed forms per year. Through its "Green Connection" program, it has developed an emissions calculator for canal users, which rewards more efficient vessels with priority passage (Panama Canal, 2023).

Cartagena is the fourth port with the highest movement of Transportation Equivalent Unit (TEU) in the region (ECLAC, 2020a). To reduce emissions generated by its operations, it has developed an energy reconversion program for yard cranes, which made it possible to maintain the level of emissions despite a 30% increase in port movements. It has also updated is lighting technology with LEDs and implemented schedules with automatic controls for air conditioning. In addition, 6,000 solar panels were installed on the roof of its distribution center, which produce 10% of the annual energy demanded by the port. This project eliminates 1,100 tonnes of CO2 emissions per year, which is equivalent to the CO2 capture of 160,000 mature trees (Grupo Puerto de Cartagena, 2021). Other ports in the region such as Caucedo in the Dominican Republic and San Antonio in Chile are making progress in the use of renewable energies, both wind and solar, reaching 100% of the energy consumed in San Antonio (Mundo Marítimo, 2023).

In their hydrogen development strategies, both Chile and Colombia identify maritime transportation as potential users of this green fuel in the long term – as from the mid-2030s–, both for ships calling at their ports and for fuel exports. In order to promote the generation of this fuel, Chile establishes five lines of action: (i) promotion of the domestic market and exports; (ii) promotion of regulations, safety and pilotage; (iii) catalyzing social and territorial development; (iv) boosting capacity building and innovation; and (v) strengthening governance. Colombia's roadmap identifies regulatory enablers, market development instruments, infrastructure deployment, and technological development as areas of work. In both cases, emphasis is placed on coordination between energy agencies and environmental and transportation agencies, in order to reconcile decarbonization policies with energy transition policies.

Despite the CC threats to ports and coastal zones, there is a generalized absence of adaptation strategies. Although some progress has been made in terms of hazard analysis, this rarely translates into long-term strategies, which contrasts with international references, where practically all ports have developed adaptation strategies. Port Authorities have been key actors in international experiences, as they have promoted the establishment of information systems, the development of climate scenarios and the identification of actions to reduce some ports vulnerabilities. Indeed, although national CC adaptation strategies in the region mention coastal zones and ports, the specificity of infrastructure and services, as well as the geographic variability of climate scenarios, require focusing analyses and actions at the port level. Hence, the Port Authorities of the region should take the lead in this task.

Compared to the regional scenario, at the international level there is growing awareness of the urgency to decarbonize and adapt the subsector, as shown by international negotiations within the IMO, maritime industry strategies, and the policies of the countries concerned. Maritime transportation is global in scope, so these actions will have an impact on the region. On the positive side, LAC port terminals belonging to international groups are already implementing actions to reduce their emissions in order to contribute to corporate goals. Shipping companies also have global goals and are seeking to generate local alliances to advance decarbonization. Some countries such as Panama and Barbados are becoming champions of sustainability in the region, the former because of the role it plays in global maritime transportation, evidencing the relationship between centrality in maritime transportation networks and progress in decarbonization; the latter due to the impact of CC on its survival. On the other hand, there is a big gap in the public policy agenda, which in turn limits the attraction of green and resilient opportunities and investments for the region.

Along with the urgency of decarbonizing shipping, there is an economic rationale for playing a role in the energy transition. Recent studies have estimated that Mexico could attract investments between USD 2 billion and 3 billion to build the electrical and net-zero fuel production infrastructure required to decarbonize 5% of the ships arriving in that country (GMF et al., 2022). In the case of Chile, the development of electrofuels could generate investments of USD 90 billion (EDF &

Investing in adaptation actions today prevents higher costs in the future.

Ricardo, 2019). Brazil, Argentina, and Colombia are also mapped among the possible centers for the production and refueling of clean fuel because of their potential in the development of renewable energies required to produce such fuel. Thus, decarbonization provides an opportunity for LAC countries to integrate into a new international maritime energy supply network.

The energy transition also has costs. There is concern that the costs of investments in new fleets of net- zero emission ships and supply infrastructure will be passed on to shippers. This is especially important for LAC countries, whose exports are highly sensitive to price variations. Studies have verified this situation for slow shipping measures, where longer transit times have resulted in higher costs for exporters in terms of product depreciation, inventory, insurance, and financing (UNCTAD, 2021). For this reason, public policy and international coordination bodies will have a key role to play to take advantage of the benefits that the industry's transformation will provide and, at the same time, mitigate the risks for the economy and society. At a time when future maritime transportation is beginning to take shape, LAC countries need to play a more relevant role on the international scene. This requires the prompt implementation of actions to build a regulatory framework and a business environment that will attract investment to the countries of the region and make it possible to achieve the emission reduction goals established at the international level.

Investing in CC adaptation actions prevents having to face higher costs in the future. As seen in Chapter 2 with the Parana-Paraguay Waterway, water transportation in the region is already being severely affected by variations in precipitation. These impacts are also evident in the Panama Canal, a critical node for maritime transportation and world trade. It is essential to incorporate adaptation actions into planning, management, and investment of these waterways without delay to avoid disruptions that could have very serious national, regional and international impacts in the future (Box 5.16).

BOX 5.16.

Potential impact of CC effects on the Panama Canal on world trade

The Panama Canal, together with the Suez Canal and the Straits of Hormuz and Malacca, is one of the four major connecting sea passages through which nearly 64% of international trade transits. The effects for world trade of what happens in these passages were demonstrated in March 2021 with the closure of the Suez Canal for six days due to the grounding of the Ever Given freighter. As a result, the price of oil rose sharply and countless companies were severely affected, from domestic transportation providers to retailers, supermarkets, and manufacturers.

The Panama Canal handles nearly 3% of global maritime trade, linking 144 maritime routes that reach more than 1,700 ports around the world. In 2022, the Canal handled 14,238 ship transits, generating revenues of USD 2.49 billion for the Government of Panama. A large amount of freshwater is consumed to operate the Canal (6,079 hm3 in 2022), especially for locks (57.8%) and hydro-generation (22.5%). This makes it vulnerable to decreased rainfall derived from CC, in response to which the Canal Authority has taken different measures. In 2019, a particularly dry year, when the basin suffered a 20% rainfall deficit compared to the seventy-year average rainfall, the Authority was forced to restrict traffic from 32 to 27 daily crossings. In 2020, a surcharge was implemented to compensate for water shortages during droughts, whereby vessels over 38.1 meters in length and 27.7 meters in beam have since paid an additional fixed price of USD 10,000 (0.7% increase in freight of a 15,000 TEU freighter). In 2022, during 12% of the days in the year, the draft was reduced from 50 to 47.5 feet due to the drought. This affected the largest container ships – the “Neo-Panamax” –, forcing them to reduce the weight by carrying less cargo. On May 24, 2023, the draft was restricted to 44.5 feet and, as of May 30, the next draft cut was to 44 feet.

Based on historical evidence and scenarios of water resource availability considering CC impacts on the Panama Canal operations over the

The effects of CC are already being felt in LAC's main transportation hubs.

next three decades, it is expected that the need to reduce the draft will mainly affect international trade from the US East Coast and the Gulf of Mexico, which account for 72% of the Canal freight (IDB, 2022). Indeed, under average conditions, the minimum draft of 50 feet for Neo-Panamax vessels will not be available during the dry season. If the current trend of decreasing the draft depth continues, it could go as low as 42 feet, severely restricting the circulation of Neo-Panamax vessels, which account for 55% of the vessels using the Canal. The products that would have a possible price increase at the regional level are petroleum and petroleum products, containerized cargo, grains, chemicals, coal, and coke. Likewise, the CC effect on the Canal would mean a decrease in revenues for the Panamanian Government of about 0.5% of GDP, considering the figures for 2022.

The roadmap below is based on international best practices, but it also considers the particular traits of LAC countries in order to advance decarbonization and CC adaptation. The suggested policy actions are organized into the four categories used in this document (strategic vision, policy instruments, institutional framework, and strategic alliances). Actions that are common to road transportation and have already been mentioned are also included here in order to have a complete perspective of the changes required in the subsector, including examples and reflections applicable to maritime transportation. Actions that are specific to the subsector are detailed, particularly regarding policy instruments. To give a time frame for implementation, suggested actions are classified into short, medium, and long term.

5.4.1 STRATEGIC VISION

As in the case of other modes, prioritizing maritime transportation decarbonization and CC resilience in the plans and strategies of the subsector is crucial to establish its importance as a policy objective. At the institutional level, the competent transportation planning authority should be in charge of this prioritization, with the participation of the ministries of environment, energy, trade, defense, and agencies connected to the maritime-port subsector. Port-level plans, prepared by the relevant Port Authorities, should be made and/or reformulated to reflect this prioritization. Based on best practices identified in Chapter 4, suggested actions to prioritize decarbonization and CC resilience in the subsector policy agenda are included below, followed by examples from the region.

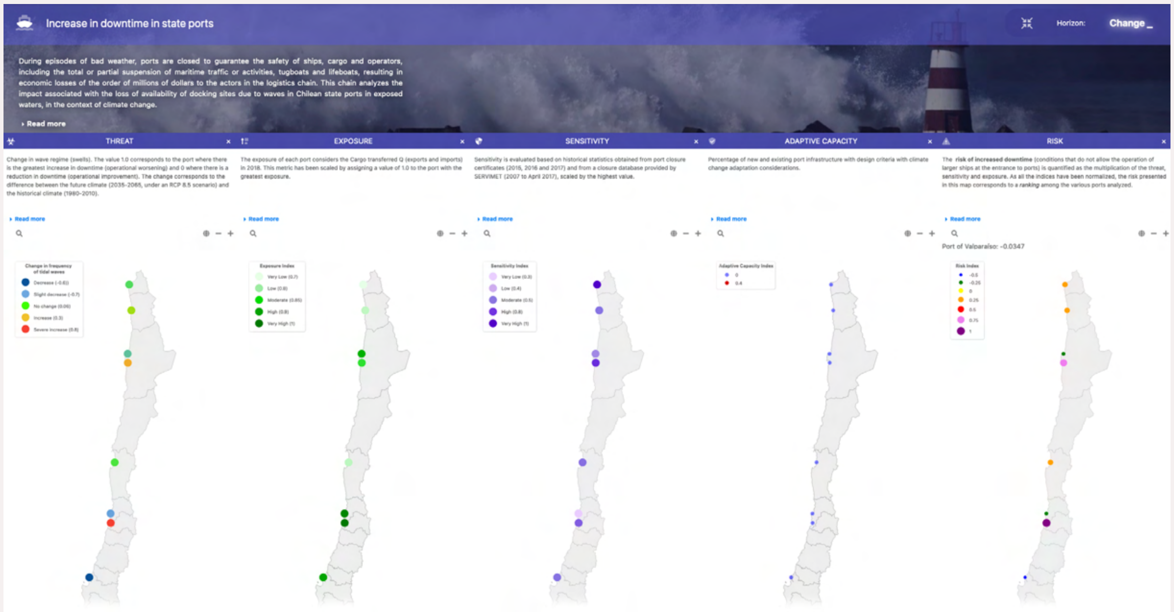
Temporality	Action
Short term (2025)	• Prepare prospective studies on the opportunities and impacts of the subsector's decarbonization in terms of efficiency, competitiveness, biodiversity, and inclusion (also covering short-term measures of the IMO strategy), which identify scenarios, opportunities, barriers, and lines of action for public policy, serving as input for plans and strategies, and for negotiations within the IMO • Identify CC risks on port infrastructure and operation, coastal zones, and intermodal connections (Box 5.17) • Consult with actors from the maritime sector, port sector, logistics sector, energy sector, academia, public agencies, civil society, and other stakeholders, with a view to incorporating CC into sectoral and subsectoral plans • Modify the transportation sector plan and the maritime-port subsectoral plan to recognize the importance of CC and its impacts, setting the vision for the future and the main lines of action around monitoring and managing CC, energy sources, intermodality, coordination with other sectors, etc. • Develop a CC action plan for the subsector that, based on prior analysis and consultations, establishes a roadmap with concrete measures to promote decarbonization and adaptation (see instruments subsection)
Medium term (2030)	• Establish emission reduction targets for the subsector, consistent with international regulations and a just transition • Within IMO, establish compensation mechanisms for developing countries that will be the most disproportionately affected by cost increases resulting from the energy transition

BOX 5.17. Risk identification for ports in Brazil and Chile

Brazil, with the collaboration of the German government, has prepared a detailed analysis of the main climate hazards, risks and impacts of CC in the country's main public maritime ports (Federative Republic of Brazil, 2021). With this information, a ranking of port affectation to 2050 was prepared, with Aratu-Candeias, Rio Grande, Paranagua, and Santos being located in the first positions regarding sea level rise.

The Chilean Ministry of the Environment has an online Climate Risk Atlas, which consists of a collection of maps with a set of impact chains organized into 12 sectors, including maritime transportation. For each chain, maps of climate hazard (A), exposure (E) and sensitivity (S) of the affected system are displayed. In the case of maritime transportation, the focus is on state ports. The three variables (A, E, S) are combined to determine the risk due to CC on the analyzed ports. The impact variable analyzed is the loss of berth availability due to waves in exposed waters, in the context of CC. According to this analysis, the ports of San Antonio and Antofagasta are the most exposed to this risk.

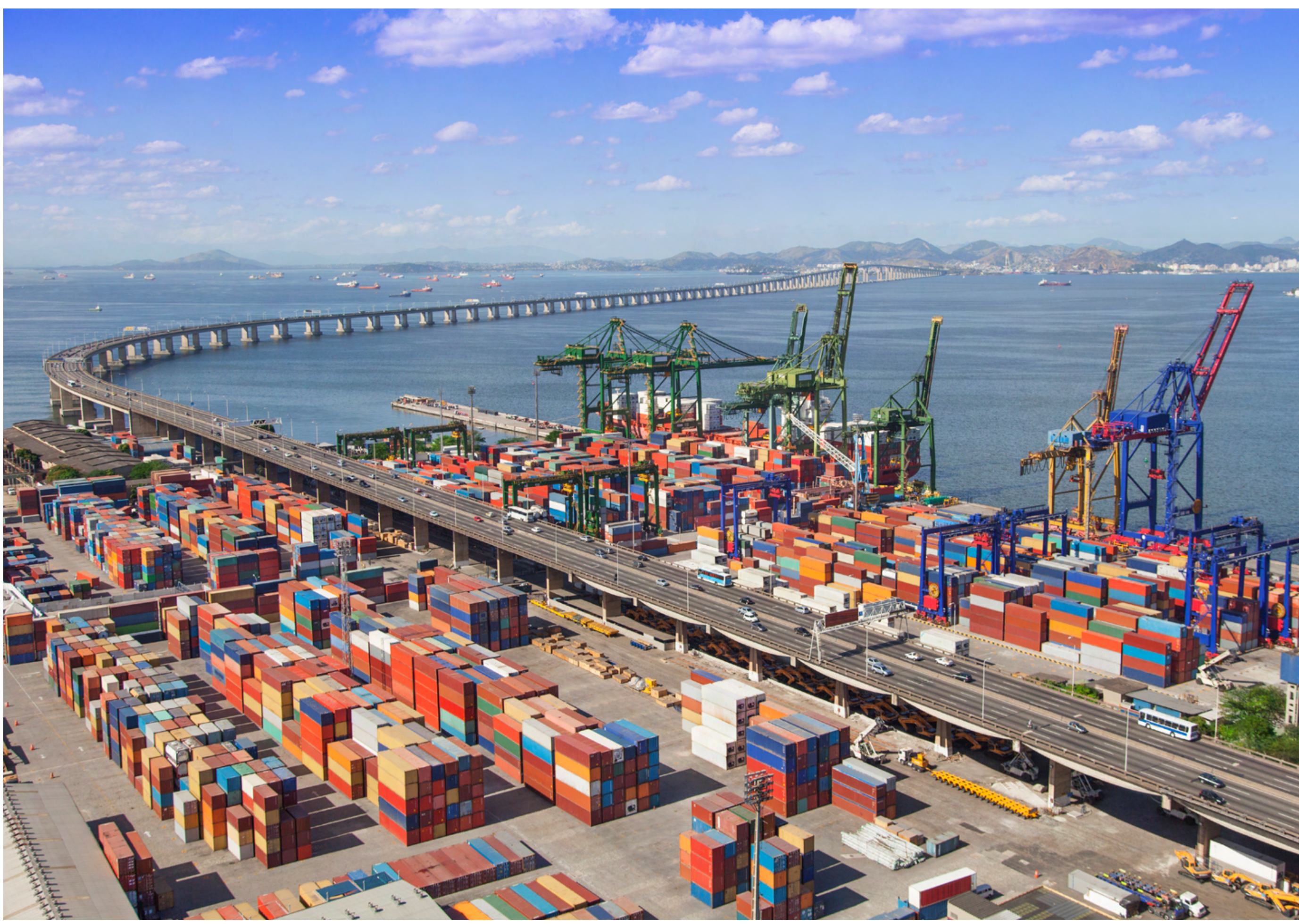
FIGURE 5.17.1 Visualization of Chile's Online Climate Risk Atlas



Source: Government of Chile (2023).

5.4.2 POLICY INSTRUMENTS

Based on prioritization, in order to advance maritime transportation's decarbonization and adaptation, actions must be combined through different types of policy instruments that the public sector possesses: regulations, public procurement, pricing instruments, non-financial incentives and investments. Adopting a flexible approach to the use and content of instruments is key given the context of uncertainty surrounding the magnitude and evolution of CC scenarios. This will allow the instruments to be chosen and calibrated according to the mitigation and adaptation pathways established at the international and national levels. The following table details the actions suggested for each of the instruments, as required in the short, medium, and long term. The boxes that follow include examples and additional information on the aspects mentioned in the actions.



Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
Regulations	• Generate and openly report terminal-level emission inventories (Box 5.18) • Reengineer administrative processes and regulatory requirements to improve operational and logistical efficiency • Establish regulatory sandboxes for testing clean and net-zero fuels • Re-evaluate design and construction standards to reduce the impact of CC • Generate climate risk monitoring and early warning systems • Establish infrastructure inspection provisions • Review land use planning to limit development in at-risk areas	• Set an emission reduction goal for the subsector at the national level • Set a goal for the replacement of equipment and vehicles by others using clean or net-zero energy • Set a goal for the use of electrical energy by ships at berth • Use a percentage of renewable energy in operations • Set emission standards and limits for trucks operating in port terminals • Establish staged reduction targets for the carbon content of fuel used by ships • Issue safety standards for production, management and disposal of new fuels • Review habitat protection measures considering new fuels and technological development	• 100% renewable energy used in terminals • Set targets for port service trucks and vessels using net-zero emissions fuels • Relocate operations away from high-risk areas
Public procurement	• Include environmental management and monitoring systems in new tenders and update concession contracts for this purpose • Include project risk analysis and CC adaptation plans in new tenders (according to adaptation pathways). Also update concession contracts for this purpose • Strengthen maintenance works within port concessions	• Formulate new tenders and update port concessions with parameters of energy performance, renewable energy use, technological modernization, and CC adaptation actions according to adaptation pathways, both in infrastructure and services (Table 5.3) • Include the vision of sustainability in tenders and authorizations for port expansions in terms of design, materials, and intermodal connections, with a high potential for innovation	• Formulate new tenders and update port concessions according to international guidelines and national goals, as well as adaptation pathways

Instrument	Temporality		
	Short term (2025)	Medium term (2030)	Long term (2050)
Pricing instruments	• Differentiate port tax for ships with lower environmental impact • Establish tax incentives for innovation and energy efficiency projects, including clean shipping hubs and green corridors • Evaluate carbon pricing mechanisms in terms of their impact on GHG reduction and the international competitiveness of the country/region • Establish penalties for loss of loading and unloading shifts in ports, in order to improve traffic management at the port-city interface	• Differentiate port tax for ships with lower environmental impact, based on the use of clean fuels • Establish tax incentives for energy efficiency innovation projects, including clean shipping hubs and green corridors • Advance the implementation of economic measures as established in the IMO framework	• Advance the implementation of economic measures as established within the IMO framework
Non-financial instruments	• Give priority passage or berthing to vessels with lower environmental impact • Facilitate permits for testing new technologies to reduce emissions, including clean shipping hubs and green corridors • Give priority access to terminals for more efficient trucks • Map capabilities for energy transition in the subsector • Create alliances with international cooperation to finance programs and foster the exchange of international experiences • Promote research applied to the transition and adaptation of the subsector, including nature-based solutions	• Give priority passage or berthing to ships with lower environmental impact, based on the use of clean fuels • Facilitate testing new technologies to reduce emissions, including clean shipping hubs and green corridors • Create a capacity-building program for energy transition in the subsector	
Investments	• Establish Port Community Systems, digital platforms and other technologies that improve the synchronization and efficiency of operations • Identify public investment needs to adapt port infrastructure, including access roads • Strengthen the maintenance of port assets	• Make the public investments required in this period to adapt port infrastructure and its respective access routes	• Make the public investments required in this period to adapt port infrastructure and its respective access routes

BOX 5.18.

Data required for the preparation of an emissions inventory according to EPA (EPA, 2022)

• Data characterizing the sources of emissions: size or capacity of the engine or power plant, type of fuel used, information on engine technology, engine model year, manufacturer, emission control technology, among others

• Data characterizing the activities: hours of operation, distance traveled according to the operating mode, number of port calls, number of cargo lifts, etc.

• Data on tests or emission factors to calculate emissions based on the energy generated or used in the activities.

TABLE 5.3 **Expiration of container terminal concessions (Top 15 2021, LAC)**

LAC Ranking (TEU 2021)	Port, Country	Beginning of concession	End of concession
1	CCT, MIT, Cristobal (Caribbean), Panama	1997	2047
2	Santos (includes Santos and DP World), Brazil	• Brazil Terminal Portuario (BTP): 2007 • Tecon Santos container terminal: 1997	• Brasil Terminal Portuario (BTP): 2027 • Tecon Santos container terminal: 2047
3	Balboa, Rodman (PSA) (Pacific), Panama	1997	2047
4	Bahía de Cartagena, Colombia	• SPRC terminal: 1993 • Contecar terminal: 1993	• SPRC terminal: 2033 • Contecar terminal: 2033
5	Manzanillo, Mexico	• CONTECON terminal: 2010 • CEMEX terminal: 1995 • Hazesa, S.A de C.V: 2013 • Cementos Apasco, S.A de C.V: 1994 • CEMEX, S.A de C.V.: 1995 • SSA México, S.S de C.V: 1995	• CONTECON terminal: 2044 • CEMEX terminal: 2043 •Marítima Hazesa, S.A de C.V: 2033 • Cementos Apasco, S.A de C.V: 2043 • CEMEX, S.A de C.V.: 2024 • SSA México, S.S de C.V: 2035
6	El Callao (public use terminals), Peru	• South Zone Container Terminal: 2006 • North Terminal: 2011 • Callao Mineral Terminal: 2011	• South Zone Container Terminal: 2036 • North Terminal: 2041 • Callao mineral Terminal: 2041
7	Guayaquil (all terminals), Ecuador	• Containers / Multipurpose terminal: 2007 • Bulk / Multipurpose terminal: 1999	• Containers / Multipurpose terminal: 2057 • Bulk / Multipurpose terminal: 2024
8	Kingston, Jamaica	• Container Terminal: 2015 - Kingston Freeport Terminal: 2015	•Container Terminal: 2045 - Kingston Freeport Terminal: 2045
9	San Antonio, Chile	• San Antonio Terminal International S.A: 2000 • DP World San Antonio: • Puerto Panul: 2000 • TERQUIM San Antonio (TQ Multipropósito contract): 2005 • Policarpo Toro Terminal (site 9): 2029	• San Antonio Terminal International S.A: 2030 • DP World San Antonio: • Puerto Panul: 2029 • TERQUIM San Antonio /TQ Multipropósito contract • Policarpo Toro Terminal (site 9): 2029

LAC Ranking (TEU 2021)	Port, Country	Beginning of concession	End of concession
10	Lázaro Cárdenas, Mexico	1994	2044
11	Freeport, Bahamas	• Freeport Container Port Limited: 1997	• Freeport Container Port Limited: 2047
12	Itajaí (incluye Portonave - Terminais Portuários De Navegantes), Brazil	• Portonave Terminais Portuários de Navegantes: 2007	• Portonave Terminais Portuários de Navegantes: 2032
13	Buenos Aires (A.M.B.A.), Argentina	• Terminal 1: 1994 • Terminal 2: 1994 • Terminal 3: 1994 • Terminal 4: 1994	• Terminal 1: 2024 • Terminal 2: 2024 • Terminal 3: 2024 • Terminal 4: 2024
14	San Juan, Puerto Rico	• International Public Terminal: 2022 • Terminal/Trailer Bridge: 2021 • Terminal de cruceros: 2022	• International Public Terminal: 2042 • Terminal/Trailer Bridge: 2041 • Cruise terminal: 2052
15	Limón+APM, Costa Rica	• Terminal de Contenedores de Moin / APM Terminal: 2018	• Moin Container Terminal (APM Terminals): 2048

Source: Prepared by the authors.

BOX 5.19.

CC and dredging

Port terminals are assets designed for long-term operation, usually between 40 to 50 years. Yet, most terminals in operation have not considered the changes in climatic variables generated by global warming as part of their design. In the future, it is expected that storms will be stronger and more frequent, which will bring about the need to dredge after these events. Likewise, the scarcity of rainfall in certain areas, such as the Parana-Paraguay waterway, will make it necessary to have greater depth of draught in access channels and docks, which will require higher levels of investment in dredging and maintenance. For example, in the port of Cartagena, the El Niño phenomenon has tripled the dredging needs due to sedimentation coming from the Canal del Dique (Ministry of Environment & Ministry of Transport, 2017). When generating adaptation strategies, Port Authorities and sectoral agencies should consider these costs to include them in public investment plans and in eventual modifications to dredging concession contracts in ports and waterways as required.

BOX 5.20.

Carbon pricing mechanisms to promote decarbonization

Since 2010, the IMO has been analyzing different measures proposed by member states for the implementation of pricing instruments to reduce GHG emissions from shipping. These measures are based on the principle that the polluter should pay for the externality generated, which leads to internalizing the costs to society of the emissions produced. The objective is that, by establishing a fee to be paid per unit of CO2 emitted, an incentive is generated to switch to net-zero emissions or zero emission fuels. On the one hand, the fee reduces the cost gap with such fuels and, on the other, resources are raised to invest in R&D and, eventually, to compensate less developed countries, which could be disproportionately impacted by an increase in transportation costs due to the energy transition. Indeed, this is one of the most important issues to be considered, which has been called for by these countries in the IMO negotiations, and which requires further analysis to move towards a just transition. In this regard, the resolution adopted by the IMO in its July 2023 negotiations recognizes the need to carry out this analysis, on whose basis to establish the features of medium-term measures for sector decarbonization, including price instruments.

BOX 5.21.

Maritime transportation decarbonization as a component of the energy transition

Maritime transportation will account for a small share of the demand for clean fuels. In this sense, the decarbonization strategy for maritime transportation must go hand in hand with the broader energy transition strategy, to consolidate enough demand for new fuels that justifies the investments required in R&D and infrastructure for their production, distribution and storage. Likewise, renewable energy sources are essential for hydrogen and ammonia production, so these sources need to be available. At the national level, this implies close coordination between government agencies in the energy and transportation sectors, so that the decarbonization strategy adopted can have the necessary energy inputs. It also involves coordinating, through the energy sector, the demand for clean fuels with other industrial sectors, both to stimulate investment and to ensure that the energy required for maritime transportation will be available. For example, analyses carried out for Mexico point to the opportunity of installing a green energy hub for the port of Manzanillo. The hub would supply for port activities and turn the port into an international bunkering center, while also providing for El Bajío and Baja California industrial zones, and benefiting from the renewable energy produced in these zones for the generation of green hydrogen and ammonia (GMF & UCL, 2022).

BOX 5.22.

International technical cooperation for climate risk analysis in ports

The port of Manzanillo accounts for nearly half of Mexico's containerized cargo, with an area of influence of 15 states, 60% of the country's GDP, and 42% of its population. The IDB has helped the Port Authority of Manzanillo producing one of the first in-depth analyses of CC impact in a LAC port, which includes a CC adaptation plan proposal identifying the actors that should lead each action and the time frame for implementation. The proposed adaptation plan was developed based on the estimation of a series of climate scenarios, hazards, vulnerabilities of the port and its associated logistics chain, and calculations of financial costs (Connell et al., 2015).

The International Finance Corporation has financed a study for the *Muelles El Bosque* Maritime Terminal in Cartagena, Colombia, which analyzed the operational, financial, legal, and environmental risk arising from changes in climate variables. Recommended actions to increase resilience included raising the height of the access road, paving key operational roads, improving drainage systems, managing cooling costs, and containing barriers to potential flooding. In addition, coordination mechanisms were identified among the actors involved in the implementation of these measures (UNCTAD, 2020).

5.4.3 INSTITUTIONAL FRAMEWORK

Institutions that govern the subsector – ministries of Transportation, port authorities, maritime directorates – must be strengthened to develop and implement the above-mentioned instruments. Likewise, given that mitigating and adapting maritime transportation to CC requires actions that are outside of the transportation entities, it is key to strengthen inter-institutional collaboration, so that the measures adopted are agreed and evaluated with sectors such as energy, environment, trade, and industry. All these actions must be carried out in the short term to have governing bodies capable of developing and implementing the strategic vision, incorporating the perspective of other agencies, and coordinating actions required in different areas of public policy, both national and international.

Level	Short term (2025)
Strengthening the capacities of public institutions responsible for maritime transportation	• Establish a permanent unit/group in charge of the elaboration, implementation, monitoring and updating of the strategy and programs related to CC within the governing body at the national level and the Port Authorities • Require the generation, systematization, and analysis of information on emissions and CC risks in order to influence the sector's planning and decision-making processes • Leverage technological changes in the subsector and institutional strategies and programs of digital transformation not only to generate information, but also to reduce emissions through digitalization (e.g. Port Community Systems, shift systems for trucks)

- Promote pilots for testing decarbonization and climate resilience solutions in the management of transportation infrastructure and services and in related processes. In this context, seek alliances with the private sector and academia for the access and implementation of solutions and the evaluation of their benefits and challenges
- Adapt the public procurement policies carried out by these entities to include emission reduction and climate resilience criteria
- Create training programs aimed at including CC adaptation considerations in the processes, tools, and infrastructure projects developed by agencies related to maritime transportation

Horizontal coordination

- Where they exist, extend the competencies of the committees (national and/or port- focused) related to maritime transportation to also include CC issues. If they do not exist, create a committee with representatives of transportation, port authorities, energy, environment, and trade control agencies, as a minimum, led by the highest authority of the executive branch in the subsector and including maritime transportation sustainability as one of its competencies. The first task of this committee should be to coordinate the strategy and regulations for decarbonization and adaptation of the subsector with the strategies and regulations on energy, environment, and foreign trade, to leverage the enabling factors and reduce barriers that could come from these sectors.
- Seek to incorporate maritime subsector representatives into committees created for other purposes but whose decisions are key to implementing sustainability actions for the subsector. For example, those related to the promotion of green hydrogen, biofuels, and resilience of coastal areas.

Vertical coordination

- Given the port's relationship with the geographic space in which it is located, the departmental and municipal levels should participate in the aforementioned committees in order to coordinate actions aimed at the subsector's sustainability. Establishing these committees within the strategies and master plans for the subsector, as well as having the highest subsector authority at their meetings, reinforces their role.
- Develop coordination mechanisms between the national and local levels to design and implement actions aimed at meeting the NDCs goals related to maritime transportation.

5.4.4 STRATEGIC ALLIANCES

As in the case of road transportation, maritime transportation is a fundamentally private business, so it is essential and urgent to integrate the sector's companies into the dialogue and the design of policy actions. Likewise, it is essential to make progress in establishing collaborative ties with academia, which plays an important role in the production of prospective studies, applied research, innovation, talent training and policy evaluation. Finally, a key aspect in maritime transportation is the coordination of actions at the regional level to promote decarbonization, considering that maritime routes serve more than one port in the region and, therefore, it will be necessary to harmonize regulations to promote energy transition, provide security in the use of new fuels, etc. Furthermore, given that several countries have similar characteristics and roles in international maritime transportation networks, it would be important to move towards shared positions at the international level – for example, in negotiations in the context of IMO –, as other regions do. This would not only strengthen action coordination, but also contribute to ensuring a just transition for developing countries.

Temporality	Action
Short term (2025)	• Form permanent working groups with representatives from port terminals, shipping companies, energy companies, freight providers, land transportation companies, and others related to maritime operations, to agree on sustainability strategies and actions at the national and port level • Establish memoranda of understanding or cooperation with the private sector and academia to promote pilots and technological deployments for decarbonization • Identify gaps in human talent and design training programs together with the private sector and academia • Share good practices and experiences with other LAC countries • Coordinate actions, generate synergies (e.g. pilots and technology deployments) and harmonize regulations at the regional level • Coordinate positions in international negotiations, evaluating the possibility of "speaking with one voice" to promote a just transition for developing countries
Medium term (2030)	• Promote pilots and technological deployments for decarbonization with the private sector and academia • Share good practices and experiences with other LAC countries • Coordinate actions, generate synergies and harmonize regulations at the regional level • Coordinate positions in international negotiations

BOX 5.23.

Pilot with the academy to promote electric river navigation in Colombia

One of the segments of maritime transportation where there is the greatest potential for decarbonization in the medium term is river navigation. In fact, smaller boats that can be propelled by electric power are normally used. While numerous projects have already been successfully implemented in Europe and Asia, experiences are scarce in LAC. The school boat developed by the Andrés Bello University, the GivePower Foundation, and the National Planning Department is a good example of a pilot that has shown the potential of electric navigation while bringing together academia, the private sector, and the public sector. The boat has the capacity to transport 21 students to and from educational centers in Bahía Málaga, on the Colombian Pacific (Universidad de los Andes, 2022). Its operation required generating a ground connection system with solar panels and establishing a remote monitoring system. More generally, Colombia has prioritized land and river transportation decarbonization within its “National Development Plan 2022-2026”, including the creation of a fund to subsidize technological development and the replacement of vessels with others using renewable energies, as well as the expansion of the provision of such energies.

5.5.
Roadmap for the decarbonization and resilience of air transportation

Although there is heterogeneity in the region regarding the prioritization of air transportation decarbonization within NDCs and LT-LEDS, several countries' aviation authorities have presented action plans to reduce CO2 emissions in the sector. These include Argentina, Bolivia, Brazil, Colombia, Costa Rica, Chile, Dominican Republic, El Salvador, Panama, and Uruguay. In addition, countries such as Brazil, Colombia, Chile, Mexico, and Paraguay, are making progress in research on alternative fuels and the deployment of energy efficiency measures. In the airport sector, in line with international best practices, there has been substantial progress in adopted measures (Box 5.24), with a considerable group of airports in the region already certified by the ACI at levels 1 to 4 (Figure 5.9).

BOX 5.24.

Progress in the region in air transportation decarbonization

A large number of airports in LAC have developed sustainability plans, identifying priorities, allocating resources and creating the corresponding teams for their implementation. Bogota's El Dorado Airport, second in passenger numbers and first in freight volume in LAC, has defined environmental sustainability as one of its management priorities. Implemented measures include using environmental metrics for the acquisition of goods and services, encouraging purchases from suppliers that take into consideration criteria to reduce water use, optimize energy consumption, and develop and implement best practices in sustainability. To this end, the concessionaire has developed a Sustainable Purchasing Manual for infrastructure operation and maintenance. It also has Level 2 "Reduction" certification from ACI, having implemented initiatives such as monitoring electromechanical systems to identify actions that reduce energy consumption, fitting more than 10,000 solar panels to meet 12% of energy consumption, purchasing renewable energies, adopting LED lighting, and using electric carts in public parking lots. This airport has also implemented compensation measures through the planting and maintenance of native trees, participation in the payment for environmental services scheme, and purchase of carbon credits.

Meanwhile, Brazil's El Salvador International Airport has implemented actions such as installing 11,000 solar panels and water reuse plants, replacing conventional light bulbs with LEDs, and reusing of solid waste. The airport's goal is to halve its carbon emissions by 2030 and achieve carbon neutrality by 2050. Since the implementation of its sustainability strategy in 2018, it has managed to reduce emissions by 30%, having also been certified at ACI Level 2 "Reduction". Operated by the same concessionaire, four airports in the Dominican Republic have their own solar plants, with more than 10,000 panels installed generating 25% of the energy used.

TABLE 5.4. **LAC airports certified by ACI**

Country	Mapping	Reduction	Optimization	Neutrality	Transformation	Transition
Argentina	1					
Mexico	16	15	4			
Brazil	4	3	1			
Peru	1	1				
Jamaica	1	1				
The Bahamas	1					
Costa Rica		2				
Chile		1				
Colombia		1				
Uruguay		1				
Ecuador				3		
Dominican Republic			6	1		
Total	**24**	**25**	**11**	**4**		

Source: Prepared by the authors based on ASI (2023)

Note: Airports located in the Oriental Caribbean, European overseas territories, and Puerto Rico are not included

However, attention to the incorporation of climate resilience measures is limited, with few cases where adaptation strategies have been developed for the subsector. Among the available examples is that of the National Civil Aviation Agency in Argentina, which has adopted an automatic system for electrical activity detection and safety protocols in 27 airports in the country (Box 5.25). On the private side, the concessionaire Opain S.A., administrator of the Bogota airport, published in 2022 the second version of its Risk and Disaster Management Plan, which takes into consideration risks and measures for infrastructure adaptation to CC. Even so, the region has yet to carry out risk or criticality assessments for its operating procedures and infrastructure in the face of increasingly adverse weather conditions, implement early risk mitigation actions, and include the potential impact of CC in its master plans.

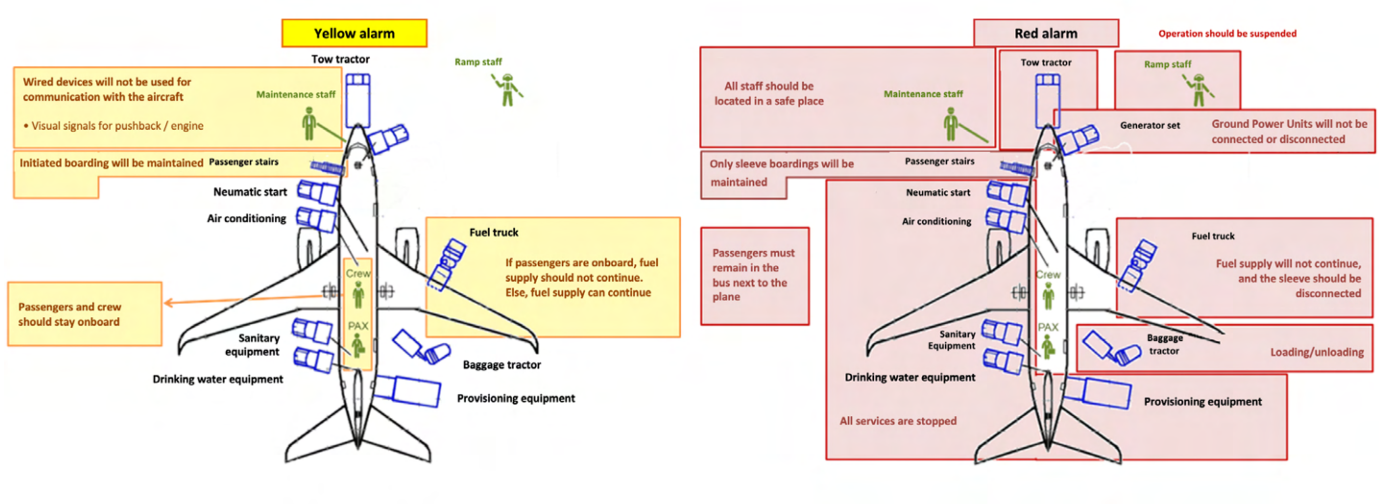
BOX 5.25.

Climate resilience at airports in Argentina

The increase in thunderstorms frequency and intensity due to CC significantly affects air transportation operations. Between 2015 and 2016, at Aeroparque Jorge Newbery in the city of Buenos Aires, 19 days/year were recorded with fuel supply outages due to electrical activity, causing average delays of 53 minutes in about 227 flights/year, and about 39 cancellations/year. To ensure the safety of ground personnel operating on the apron, while maintaining efficient dynamics, in October 2018 the National Civil Aviation Agency arranged to install an automatic electrical activity detection and warning system, along with the implementation of standardized safety protocols for cessation and restart of apron activities. This system works through a network of sensors that map electrical activity in the sky and trigger alarms that initiate the protocols. A radius of 8 nautical miles was established for the yellow alarm and 3 nautical miles for the red alarm. The alarms are automatically communicated by visual and audible devices on the platform, and by SMS/e-mail to those involved in the operation, indicating the cessation and restart of activities. The system and alarms were installed in 27 airports in the country within a year.

FIGURE 5.24.1

Platform safety protocol in case of electrical activity in Argentina



Source: ANAC (2018).

Using the four categories of policy measures proposed in this paper, the roadmap for preparing the subsector as a whole to contribute to achieving Paris Agreement goals and reducing vulnerability to CC is presented below.

5.5.1 STRATEGIC VISION

The roadmap should start by identifying decarbonization and resilience as public policy priorities for air transportation. This should be reflected in the transportation plan and existing plans or strategies at the subsector level. It is key that this action is carried out in the short term, since such prioritization will facilitate the implementation of policy instruments (see subsection 5.5.2) to advance decarbonization and CC resilience. At the institutional level, this prioritization of decarbonization and resilience within the strategic vision for the air mode should be generated by the National Civil Aviation Agency, with the participation of the ministries of Energy, Environment, and agencies related to the aviation subsector. The aviation authorities should ensure that airport-level master plans, generally prepared by terminal operators, are carried out and/or reformulated along the guidelines of this prioritization. Suggested actions to achieve this prioritization, based on best practices identified in Chapter 4, are included in the table below.

Temporality	Action
Short term (2025)	• Coordinate workgroups with public and private actors (e.g. airlines, aircraft manufacturers, fuel and biofuel suppliers, airport operators, academia, government authorities, etc.) to develop a decarbonization roadmap for the sector • Develop feasibility and life cycle studies for potential inputs and routes of production of alternative aviation fuels (SAF) • Coordinate with national hydrogen strategies to contemplate production of synthetic aviation fuels • Develop national plans for airport systems and their respective investment plans based on the analysis of airport infrastructure vulnerability to hazards generated by natural disasters and CC, and coordinate them with urban master plans
Medium term (2030)	• Incorporate emission reduction initiatives into NDCs and LT-LEDS • Establish emission reduction targets for the subsector consistent with the international objectives of the activity

5.5.2 POLICY INSTRUMENTS

LAC's public sector can leverage the experiences and best practices of benchmark countries to create instruments that boost decarbonization and resilience of air transportation. As in the maritime case, given the uncertainty around technologies and evolving CC scenarios, a flexible approach will be required, whereby instruments are chosen and calibrated according to the mitigation and adaptation pathways to be established at the international and national levels. The table below presents the suggested actions classified in short, medium, and long-term time frames.

Instrument	Temporality	
	Short term (2025)	**Medium term (2030)**
Regulations	• Design and implement public policies that include incentive programs for emission reductions, incentives for SAF production, sustainability certification schemes, carbon measurements, carbon markets, or other initiatives to promote and facilitate emission reductions • Define sustainability criteria for biofuels that are considered as SAF, to contain impacts on agricultural production, biodiversity, and potential changes in land use • Establish policies for the implementation of emission inventories, monitoring reports, and voluntary reduction targets by sectoral actors • Incorporate in state airports and airport concessions: energy performance parameters, use of renewable energies, CC adaptation actions, emissions monitoring and reduction, and their adherence to programs such as ACA from ACI. • Digitize all processes and procedures in the commercial air operation of passengers and cargo, including all public agencies (e.g., customs, health, migration, security, etc.) and their integration with private operators • Promote executive lines of ecological buses between airports and cities through concessions and/or financial incentives to reduce the use of private vehicles and/or taxis in airport transfers • Grant authorizations for expansion of airport capacity in urban areas conditional on contributions to the investment required to increase public transportation access to the airport	• Adhere to ICAO's CORSIA program (carbon offsetting and reduction) • Formulate future tenders and renegotiation of airport concessions according to international guidelines and national emission reduction goals, as well as CC adaptation actions • Implement, in conjunction with airport operators and airlines, the rules for allocation of slots (WASG) at airports with high congestion (level 3)
Public procurement	• Establish technical criteria for procurement of goods and services considering environmental metrics, stimulating purchases from suppliers that adopt criteria for reducing water and energy consumption, and implementing best sustainability practices	• Formulate new tenders and update airport concessions incorporating parameters of energy performance, use of renewable energies, risk analysis in projects, and CC adaptation actions

Pricing instruments	• Establish public procurement schemes and/or economic and/or financial incentives for the provision of SAF • In current airport concessions, evaluate the offer of economic and/or financial incentives to implement sustainability measures (e.g. renewable energy generation plants, energy efficiency programs, electrification of fleets, tools for monitoring and accreditation of carbon emission reductions, etc.) • Offer economic and/or financial incentives to public transportation companies taking passengers to airports	• Offer reduced air traffic control fees for aircrafts with lower environmental impacts, based on their energy efficiency and the use of clean fuels • Implement emission rights and carbon pricing instruments for emission reduction and offsetting
Non-financial incentives	• Map capacities for energy transition in the subsector • Create alliances with international cooperation to finance programs and promote the exchange of international experiences • Promote research applied to the transition and adaptation of the subsector, including nature-based solutions • Incorporate state-managed airports into ACI's ACA program	• Create a capacity building program for energy transition in the subsector
Investments	• Optimize airspace design, and implement air traffic management (ATM) programs and investments in airport and air navigation infrastructure that contribute to reducing air congestion, increasing efficiency and improving operation safety • Identify public investments inside and outside the airport area necessary for CC adaptation • Install automated meteorological centers that allow early detection of climatic phenomena that may affect airport operations • Implement plans for emissions monitoring and reduction, international certifications, renewable energy use, and actions to adapt to CC at state-managed airports • Incentives for public and private energy companies to leverage SAF production	• Make the necessary public investments to adapt to CC • Implement plans for constant modernization of air traffic management infrastructure (surveillance, navigation, and aeronautical communications) • Invest in sustainable public transportation connected to major airports (e.g. extension of metro lines) and adapt public transportation for passenger comfort (e.g. luggage space)

BOX 5.26.

Alliances with multilateral organizations for air transportation decarbonization

Over the last decade, the IDB has helped numerous countries in the region improve local and regional connectivity and integration, airport infrastructure quality, air navigation systems' efficiency, and the design of safety, environmental sustainability and affordability standards. As a result of IDB collaboration, 13 national air navigation policies were designed, 19 countries were supported in improving operational safety, and more than 340 officials were trained in air regulation and airport management. In the area of airport infrastructure, the IDB Group, through its public (IDB) and private (IDB Invest) arms, has mobilized more than USD 1.9 billion for the renovation and rehabilitation of 26 airports in LAC. In particular, the IDB actively supports the development of sustainable aviation fuels, working with aviation authorities and airlines on a wide range of activities. These include financing pilot flights with SAF, conducting studies of SAF inputs' value chains and analysis of carbon emissions throughout their life-cycle, organization and participation in events to promote SAF, and, more recently, the coordination of public-private roundtables for the elaboration of SAF development roadmaps.

BOX 5.27.

Promoting CC mitigation and adaptation in public airports

In Bolivia, the airports of Tarija and Uyuni will receive public investment, facilitated through an IDB loan, to improve infrastructure with safety and sustainability criteria. This investment includes mitigation and adaptation actions in airport buildings, promoting the use of energy and water efficiency standards to achieve EDGE (Excellence in Design for Greater Efficiencies) green building certification. Other measures include improving thermal insulation in terminals and efficiency in sanitary and lighting equipment to enhance the airports' energy efficiency and reduce their environmental impact. The project also seeks to promote photovoltaic energy generation at the Uyuni airport to reduce dependence on non-renewable sources, and the installation of a wastewater treatment plant to reuse water efficiently. Another important measure is using recycled construction materials on runway shoulders, which will reduce the environmental impact generated by construction and reduce the amount of waste generated. Also worth mentioning is the improvement in solid waste management with the separation and recycling of waste at the airport facilities. By obtaining EDGE certification, the Tarija and Uyuni airports will not only contribute to reduce their environmental impact, but also to achieve global goals established in the Paris Agreement and the SDGs. This is an important step towards a more sustainable and environmentally friendly future in the aviation sector, and an example for other airports in the region to follow.

• 5.5.3 INSTITUTIONAL FRAMEWORK

To develop and implement the aforementioned actions, it is key to strengthen the institutions that govern the subsector – ministries of Transportation, Civil Aviation Authorities – and promote inter-institutional collaboration with sectors such as energy, environment, trade and industry, which have mandates on functional areas for decarbonization and resilience of air transportation. As in the case of the other subsectors, these actions must be carried out in the short term to have governing bodies capable of developing and implementing strategic prioritization, incorporating the perspective of other agencies, and coordinating actions required in different areas of public policy, both national and international.

Level	Short term (2025)
Strengthening the capacities of public institutions	• Establish a permanent unit/group in charge of creating, implementing, monitoring, and updating CC strategies and programs within the National Civil Aviation Authorities • Require the generation, systematization and analysis of information on CC emissions and risks, in order to influence planning and decision-making processes in the sector • Leverage technological change in the subsector and institutional strategies and programs for digital transformation not only to generate information, but also to reduce emissions through digitalization • Promote pilots for testing decarbonization and climate resilience solutions in infrastructure management and operations. In this context, seek partnerships with the private sector and academia for the access and implementation of solutions and evaluation of their benefits and challenges • Adapt these entities' public procurement policies to include emission reduction and climate resilience criteria • Develop training programs aimed at including CC adaptation considerations in the processes, tools, and infrastructure projects developed by agencies related to air transportation
Horizontal coordination	• Coordinate decarbonization and resilience actions in the aviation sector with master plans in the areas of influence of airports, especially in terms of urban planning and transportation, for greater effectiveness of interventions • Incorporate the issue of emission mitigation and CC adaptation at Airport Collaborative Decision Making (ACDM) committees

	• Participate as a subsector in committees on other topics whose decisions impact the sustainability of air transportation, such as climate change committees, energy transition, hydrogen, biofuels, protection of coastal areas, etc. • Establish alliances with public bodies and the private sector to develop and implement circular economy plans in and around airport businesses
Vertical coordination	• Implement, in coordination with national and subnational authorities, management and investment plans to promote the use of public transportation and improve vehicular access to airport passenger and freight terminals • Develop coordination mechanisms between the national and local levels to design and implement actions aimed at meeting NDC goals related to air transportation

5.5.4 STRATEGIC ALLIANCES

Advancing the decarbonization and resilience of air transportation depends on close public-private coordination involving government agencies, airport concessionaires, airlines, and ground service providers. Academia also has a role to play in this transition, especially in promoting R&D, talent training and policy evaluation. Generating alliances with these sectors should be part of the short-term actions in this subsector.

Temporality	Action
Short term (2025)	• Form permanent workgroups with representatives of airports, industry and airlines, energy companies, and other actors related to airport operations, to share best practices and reach consensus on sustainability strategies and actions at the national and airport levels • Participate in working teams of international sectoral organizations to share best practices and incorporate experiences • Identify gaps in human talent and design training programs together with international aviation organizations, the private sector, and academia • Establish memorandums of understanding or cooperation with the private sector and academia to promote pilots and technology deployments for decarbonization

BOX 5.28.

Promoting alliances with private and public entities for the reduction of emissions

There are numerous examples of multi-sector partnerships to implement circular economy measures at airports. For example, in the case of Bogota's El Dorado airport, alliances have been established with Ecopetrol, Coca-Cola Femsa, the Secretariat of the Environment, the Ministry of the Environment, Sistema Verde, the International Solid Waste Association, and GIZ, for the implementation of the Circular Economy Plan. Through this initiative, the following measures were implemented: (i) the first stretch of road paved with modified asphalt containing recycled plastic was inaugurated on the airport's access roads; (ii) reduction of single-use materials, with initiatives such as maintenance and repair of cargo vehicles; and (iii) reuse of electronic waste and implementation of the Zero Paper Policy. As a result, 66% of the airport's waste was reused in 2022, 41% of which was organic waste from composting and 25% from materials recovered in the separation process.

5.6.
Conclusions of the roadmaps for LAC

• Although there are some interesting experiences in the region, such as some cities' leadership in the transition to an electric fleet for public transportation, in general LAC lags far behind in terms of readiness to decarbonize and adapt transportation to CC.

• To close this gap, the experiences of benchmark countries show that actions are required in four categories: (i) identifying decarbonization and resilience as sector priorities, within a vision of efficient, inclusive and sustainable transportation; (ii) developing policy instruments to realize the vision; (iii) adapting institutions to address the task of decarbonization and climate resilience of the sector; and (iv) generating strategic alliances with government agencies and with the private, academic and civil society sectors, in order to drive a transition that requires systemic change in transportation.

• However, it is necessary to recognize the economic, social, and environmental context from which LAC countries start out, with a much lower contribution to global emissions than advanced countries, with serious fiscal and social challenges, and with an infrastructure gap that it needs to close to reduce poverty and inequality. As stated in the Paris Agreement for developing countries, the region needs a just transition.

• LAC needs to deploy a battery of funding and financing mechanisms to guarantee the necessary resources for the sector to develop efficient, inclusive, and sustainable transportation systems. Closing the gaps in the sector implies improving the efficiency of funds and instruments used, and exploring innovative funding and financing mechanisms. In this regard, financial instruments associated with CC and sustainability represent an opportunity for the region, in addition to the need to significantly increase the volume and improve the efficiency of traditional financing and funding mechanisms available in the sector.

• Within the framework of a just transition, there are low-cost, high-impact measures that countries from the region can implement in the short term. For instance, including the fight against CC as one of the pillars of public transportation policy, updating planning documents and sectoral regulations, strengthening institutions, creating training programs on new technologies and methods of energy transition, strengthening international cooperation, and generating alliances with the private and academic sectors. The aim is for LAC countries, in the context of a just transition, to create the enabling framework that will catalyze the investments needed in the medium term to move towards net-zero transportation by 2050.

• CC provides an unprecedented opportunity to change the transportation model. The aim should not just be to replace fossil fuels with other energy sources, but also to achieve more sustainable, efficient, safe, and inclusive transportation that provides equal access to opportunities for all. In this context, it is essential to change how people and goods move, based on specific strategies for each mode of transportation, coordinated with actions in other areas of government, and under the umbrella of a national plan that establishes the vision and general guidelines for the sector. The government has an important role in the materialization of this vision, but successful implementation will come from the generation of alliances with other public agencies, the private sector, academia, and civil society.

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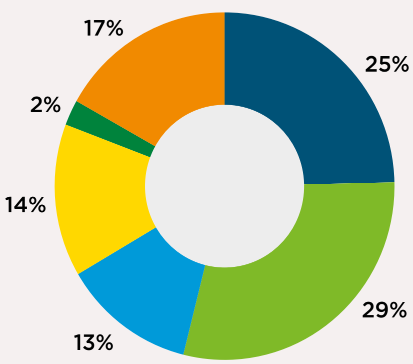
Annex: Transportation and climate change profile of LAC countries

Argentina

1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

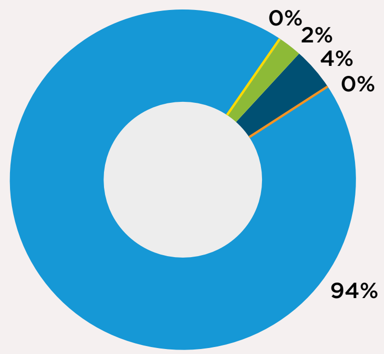


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2018), the transportation sector emitted a total of 50.22 tonnes of CO2, equivalent to 13.9%.

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ Yes ○ NO

- **Mitigation measures proposed in NDC**

SHIFT

Measures aimed at modifying the mode of transportation

1. Urban passenger transport: developing sustainable and low emission mobility (vehicle energy efficiency labeling, promoting buses that run on alternative energy sources, promoting light- duty vehicles with low-emission technologies, renewing bus fleet (Euro III to Euro V), and promoting active mobility).
2. Prioritizing freight rail: designing a freight rail investment and sustainable transportation plan.

Argentina

Improve	Actions aimed at improving transport systems efficiency	1. Improving the efficiency of road freight transport: B-trains and scalable trucks, Smart Transportation Program (including training for drivers), fleet renewal with truck scrapping (National Road Plan for 2025). 2. Inland waterways freight transport: fleet renewal with alternative energies. 3. Promoting the use of natural gas and electricity in the transportation sector in general.

3.
Coherence of NDC measures with plans and policies

National policies/measures

• National Climate Change Adaptation and Mitigation Plan 2030.

Subnational policies/measures

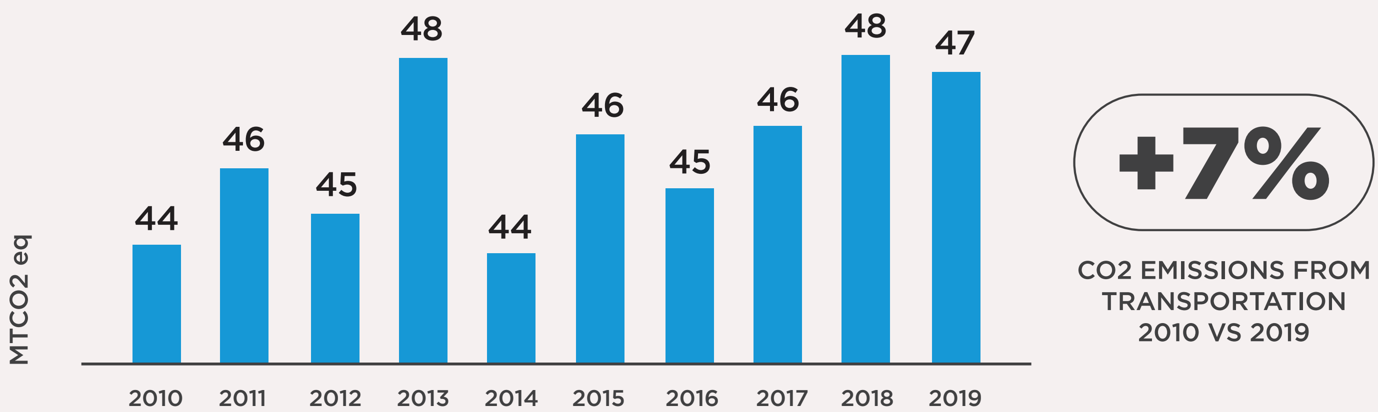
• Climate Action Plan (City of Buenos Aires / Rosario / Mendoza).

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	●	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	●	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	○	●
Mitigation goals for transportation in NDC	○	●

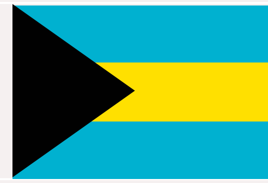
Argentina

Evolution of CO_2 emissions from the transportation sector (2010-2019)



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Bahamas



1.
CO2 emissions derived from fuel combustion (2019)

Data Unavailable at IEA*

Data on Bahamas' emissions is available at:
https://ourworldindata.org/co2/country/bahamas

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Encouraging the use of public transportation.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Promoting the electrification of road transportation. **2.** Improving incentives to purchase electric vehicles. **3.** Assessment of government vehicles and program to replace suitable vehicles with electric vehicles. **4.** Introducing electric vehicles into the government fleet. **5**. Installing charging stations for electric vehicles.

3.
Coherence of NDC measures with plans and policies

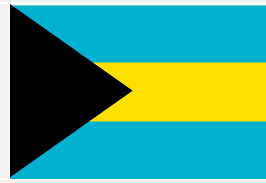
National policies/measures

- National Energy Policy 2013 -2033.
- National Policy on Adaptation to Climate Change.
- National Maritime Policy.
- Marine Protection Plan.
- National Development Plan 2040.

Subnational policies/measures

N/A

Bahamas



4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

Barbados

1.
CO2 emissions derived from fuel combustion (2019)

Data Unavailable at IEA

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	**1.** As of April 2021, the government's procurement policy is to prioritize purchasing electric or hybrid vehicles. **2.** Barbados Transport Board aims at operating an entirely electric fleet by 2030.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A.

3.
Coherence of NDC measures with plans and policies

National policies/measures

- Barbados National Energy Policy 2019 – 2030.
- Barbados National Climate Change Policy.

Subnational policies/measures

- A Sustainable Urban Mobility Plan for the Bridgetown Metropolitan Area and Urban Corridor.
- Urban renewal in the corridor from Pile Bay to Harts Gap, Bridgetown Market, Fishing Harbor, and Greater Carlisle Bay.

Barbados

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

Belize

1.
CO2 emissions derived from fuel combustion (2019)

Data Unavailable at IEA

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO Avoid 117 KtCO2eq/year from the transportation sector by 2030

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Improving the efficiency of the public transportation system by deploying 77 hybrid and electric buses by 2030. **2.** Implementing a policy framework to promote more efficient vehicles and alternative fuels/mixes by adding fuel economy labels; emissions tests; fuel economy standards; limitations and taxes/reimbursements based on emissions for imported vehicles by 2025. **3.** Improving passenger electromobility.

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Policy, Strategy and Action Plan on Climate Change.
- E-Mobility Pilot Project.
- Belize Comprehensive National Transportation Master Plan.

Subnational policies/measures

N/A

Belize

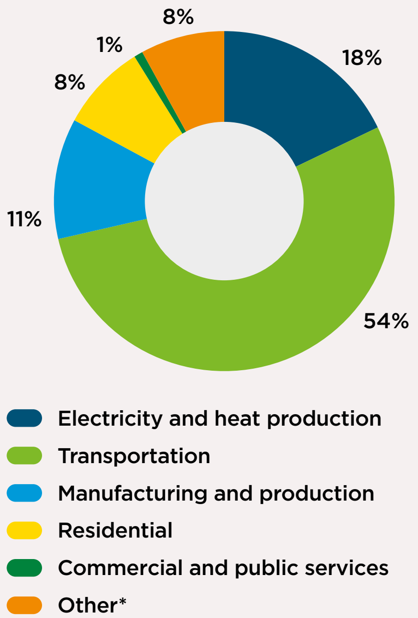
4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	●	○

Bolivia

1.
CO2 emissions derived from fuel combustion (2019)

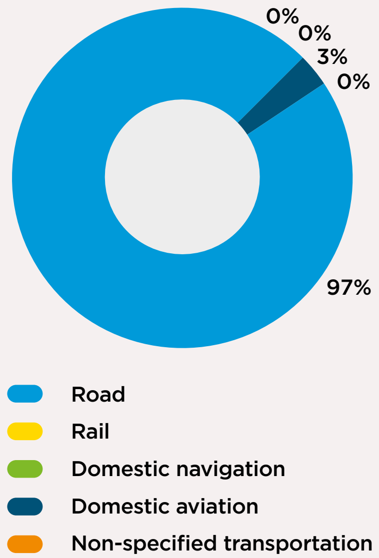
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to Balance Energético Nacional (2020), the transportation sector emitted a total of 5,265.49 Gg of CO2.

B. Emissions by transportation mode



Source:IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

(●) YES ( ) NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** 10% annual increase in the share of electric vehicles within the public transportation fleet by 2030.

Bolivia

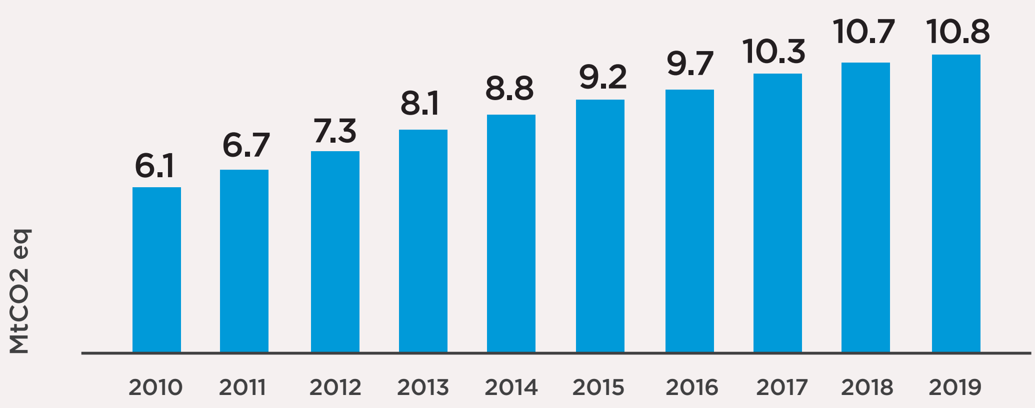
3.
Coherence of NDC measures with plans and policies

National policies/measures	Subnational policies/measures
• Electric mobility strategy. • Bolivian Action Plan for the Reduction of Emissions in the civil aviation sector.	N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	●	○

• **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+78%

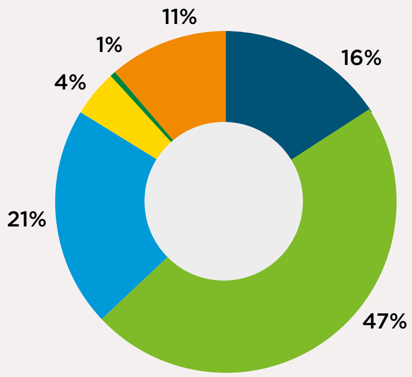
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Brazil

1.
CO2 emissions derived from fuel combustion (2019)

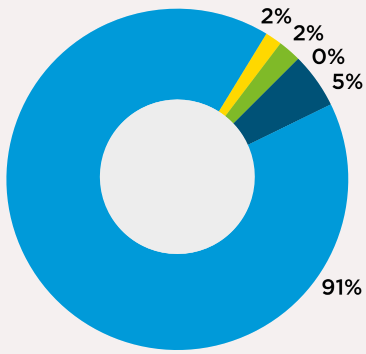
A. Emissions by sector



- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

○ YES ◉ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Brazil

3.

Coherence of NDC measures with plans and policies

National policies/measures

- National Urban Mobility Plan.
- Tax incentive policy for the development of electric mobility and research.
- Energy transport policy for 2030.
- RenovaBio.
- National Climate Change Policy.

Subnational policies/measures

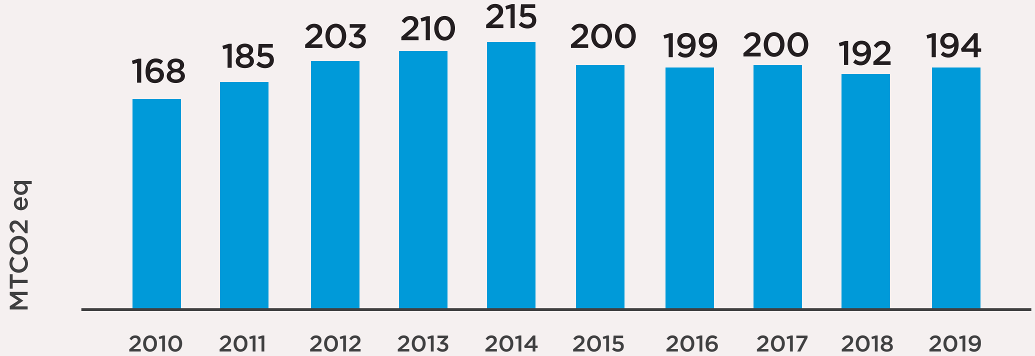
- Bi-articulated Electric Bus.
- Bicycle Brazil Program.
- Cycling Cities Rio de Janeiro.
- Cycling Cities Recife.
- Clean Mobility District for Rio de Janeiro.
- Cycling Expansion Plan - Rio de Janeiro.
- URBAN95-Recife.

4.

Adoption of UNFCCC mechanisms

National Adaptation Plan sent to UNFCCC (NAP)	YES
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	YES
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	NO
National Adaptation Program of Action sent to UNFCCC (NAPA)	NO
NDC presented	YES
Transportation is prioritized in NDC	NO
Mitigation goals for transportation in NDC	NO

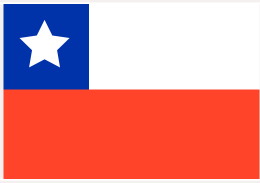
- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+15%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

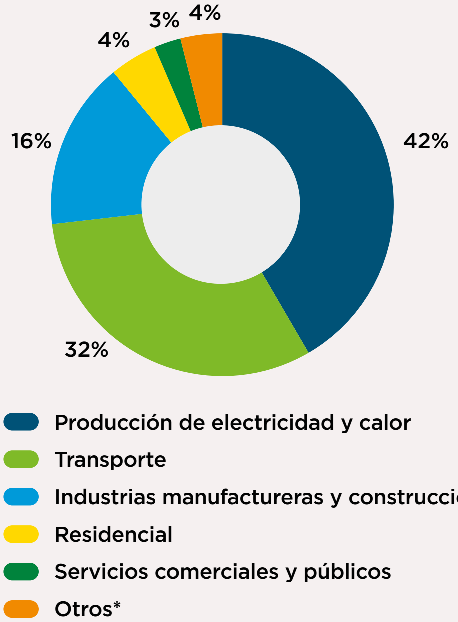
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en



Chile

1.
CO2 emissions derived from fuel combustion (2019)

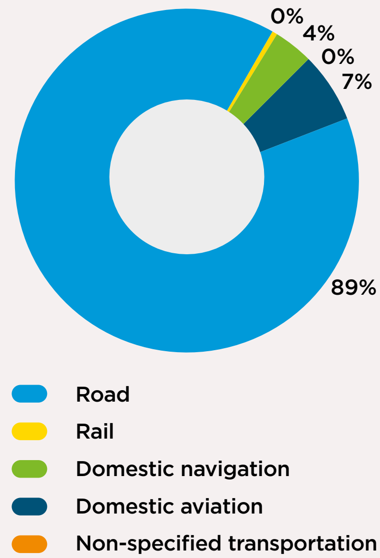
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

*__Note:__ According to INGEI (2021), the transportation sector emitted a total of 28,614 MtCO2, equivalent to 25%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Reducing private motorized transportation and replacing it with buses and bicycles.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Electromobility in taxis and urban public transportation. **2.** Hydrogen-powered freight transportation.

Chile

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Sustainable Mobility Strategy (ENMS, after its Spanish initials).
- National Electromobility Strategy (2022).
- National Green Hydrogen Strategy (EH2V).
- National Energy Policy 2050 (PEN).
- Energy Efficiency Law.
- National Energy Efficiency Plan.
- Long Term Climate Strategy.
- Framework Law on Climate Change.

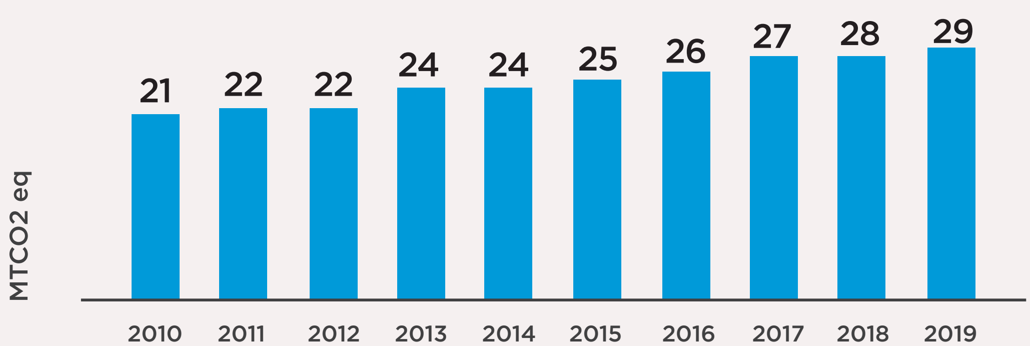
Subnational policies/measures

- Electrification of Public Transportation in Santiago and regions.
- Santiago's Metropolitan Mobility Plan 2030.

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	◉	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	◉	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	◉	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**



+34%

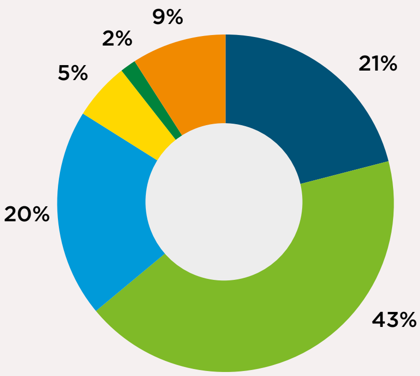
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Colombia

1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

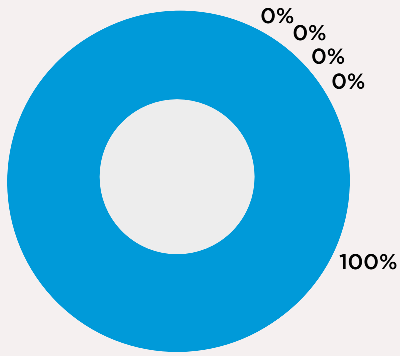


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2012), the transportation sector emitted a total of 28.2 Mtonne of CO2.

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

AVOID	Measures aimed at reducing the demand for transportation	**1.** Optimizing freight logistics.
SHIFT	Measures aimed at modifying the mode of transportation	**1.** Freight mode shift from road to inland waterways – Magdalena River. **2.** Active Transportation and Travel Demand Management (TAnDem). **3.** Rehabilitating the La Dorada - Chiriguana – Santa Marta rail corridor.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Electric mobility: 600,000 electric vehicles by 2030. **2.** Performance-Based Air Navigation (PBN). **3.** Road Freight Transportation Modernization Program.

Colombia

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Active Mobility Strategy with gender and differential perspectives.
- National Electric mobility strategy.
- E2050 Colombia.
- Policy to Modernize the road freight transportation sector.
- Electric Mobility Law (Law 1964 of 2019).
- Climate Action Law (Law 2169 of 2021).

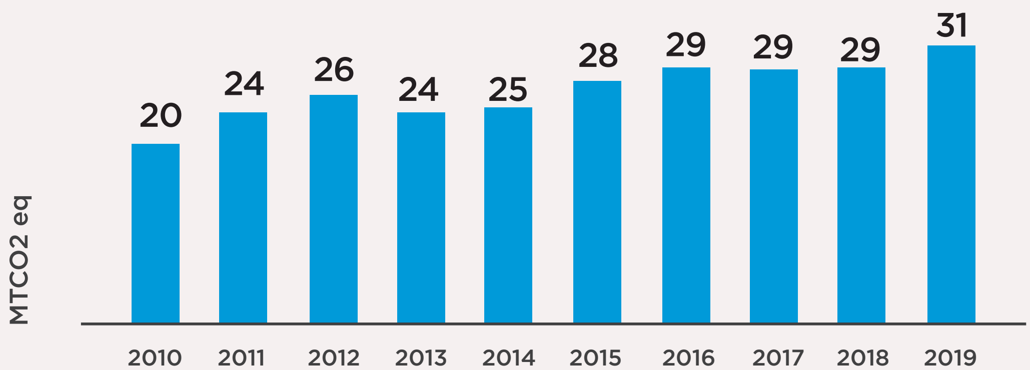
Subnational policies/measures

- Integrated public transportation systems in 7 major cities and 8 intermediate cities.
- Electric bus fleet in Bogota, Medellin and Cali.
- Electric taxi pilot in Bogota and Medellin.
- Electric mass transportation by rail or cable (Bogota, Medellin, Cali, Manizales).
- Public space projects focused on sustainable mobility (e.g., green corridor in Bogota, Pichincha corridor in Medellin, public bicycle systems in Bogota, Medellin, Palmira, Montería).
- Congestion pricing (Bogota, Cali).

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	●	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	●	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	●	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

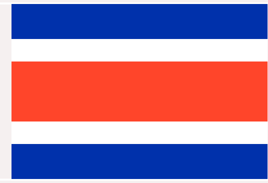
- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+54%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

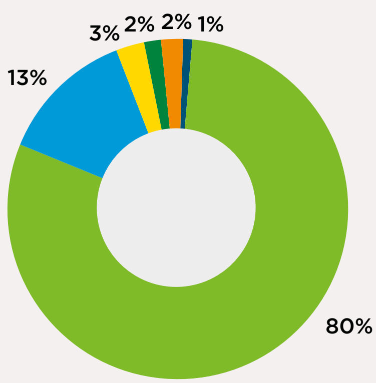
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en



Costa Rica

1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

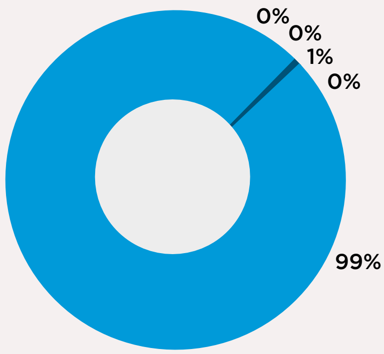


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2017), the transportation sector emitted a total of 6,017.2 Gtonne of CO2, equivalent to 52%.

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

(●) YES ( ) NO

• Mitigation measures proposed in NDC

AVOID Measures aimed at reducing the demand for transportation

1. Establishing sustainable logistics models in the country's main ports, urban areas, and logistics consolidation centers.
2. Reducing the digital and technological gap to increase digital practices such as teleworking, e-commerce, and virtual tourism - which reduce the need to travel.
3. Promoting policies that allow remote work in government institutions and public and private enterprises.

Costa Rica

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Operating the Greater Metropolitan Area Electric Passenger Train, running on renewable electric energy. **2.** Operating the Limon Electric Freight Train (TELCA, for its abbreviation in Spanish). **3.** Expanding and improving infrastructure to increase non-motorized mobility by at least 5% (including pedestrian and bicycle mobility). **4.** Encouraging low-emission urban development patterns by integrating the perspective of transit-oriented development in planning and land management instruments.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Renewing public bus concessions with decarbonization criteria, including division by geographic sectors, electronic payments, and multimodal integration of public and active means of transportation. **2.** Achieving at least 8% in the share of zero emission vehicles within the country's public transportation fleet. **3**. Establishing sustainable logistics models in the country's main ports, urban areas, and logistics consolidation centers. **4.** Adopting actions to achieve a zero-emission motorcycle fleet and stabilize its growth. **5.** Achieving at least 8% in the share of electric vehicles within the light-duty vehicle fleet (private and institutional). **6.** Implementing the Green Hydrogen strategy for transportation.

3.
Coherence of NDC measures with plans and policies

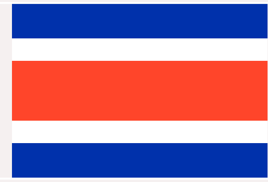
National policies/measures

- Costa Rica's National Decarbonization Plan 2018-2050.
- Comprehensive reform for the new Bicentennial institutional framework.
- Green Fiscal Reform.
- Costa Rica's National Green Hydrogen Strategy 2022-2050.

Subnational policies/measures

- Intermunicipal Transit-Oriented Urban Development Plan.
- Municipal Sustainable Mobility Plan.
- Municipal Climate Action Plan.
- Intermunicipal Active Mobility Network.
- Municipal Electric Mobility Plan.

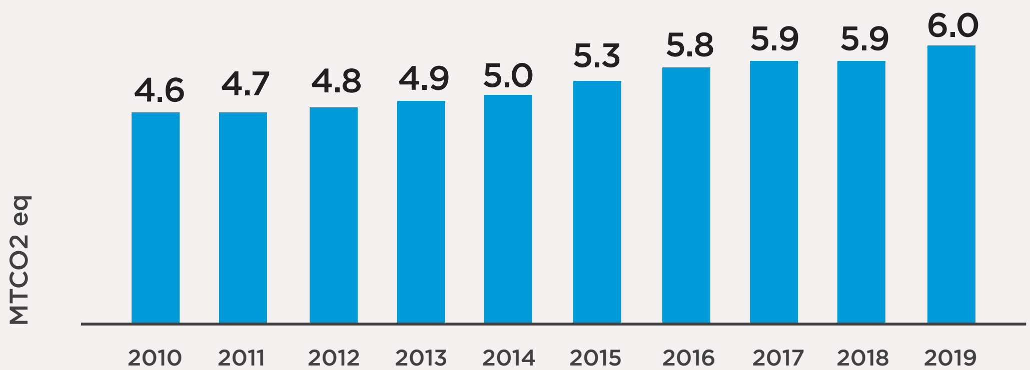
Costa Rica



4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	◉	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	◉	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	◉	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

• **Evolution of CO_2 emissions from the transportation sector (2010-2019)**



+31%

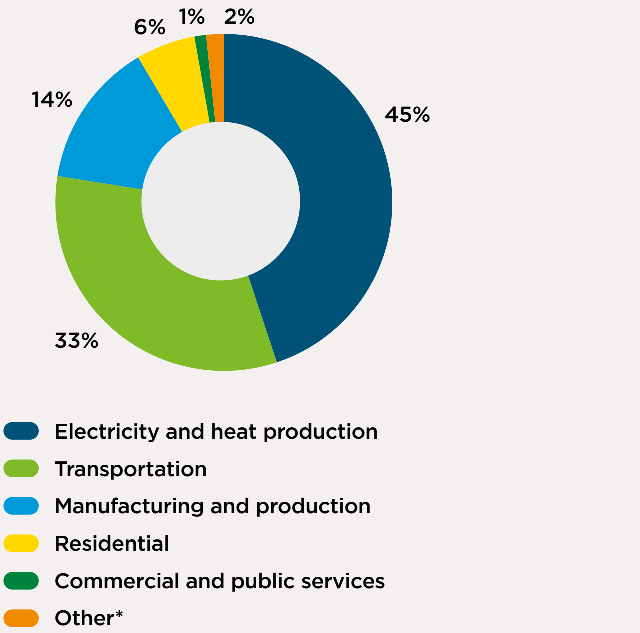
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Dominican Republic

1.
CO2 emissions derived from fuel combustion (2019)

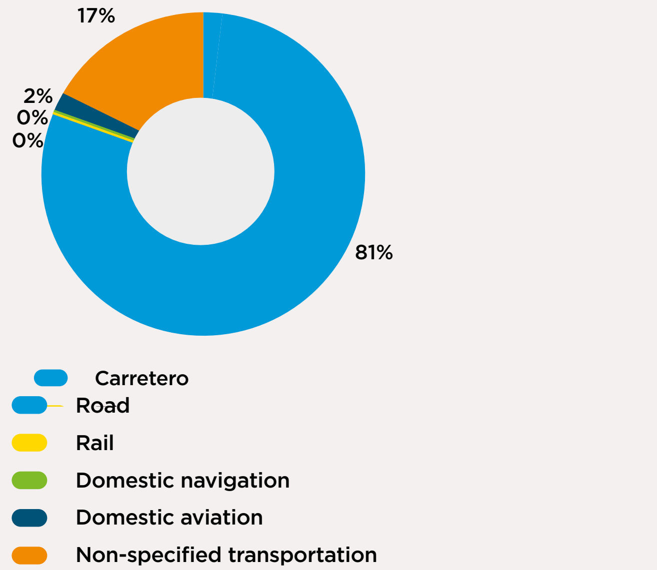
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2015), the transportation sector emitted a total of 7,635.83 Gg of CO2, equivalent to 21.5%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Extending and developing new routes for 42 kilometers of metro stations in Santo Domingo. **2.** Eleven kilometers of new lines in Santo Domingo's cableway powered by electricity. **3**. Adapting networks for cycle paths in main cities and promoting bicycle use for trips of less than 8km.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Renovating the bus fleet, using more efficient technologies. **2.** Renovating taxis and collective taxis (or conchos), using more efficient technologies. **3.** Modernizing the private vehicle fleet with more efficient technologies.

Dominican Republic

3.
Coherence of NDC measures with plans and policies

National policies/measures

- Electric Mobility Law.
- National Strategy for Electric Mobility.
- Implementing the "National Vehicle Technical Inspection" program.

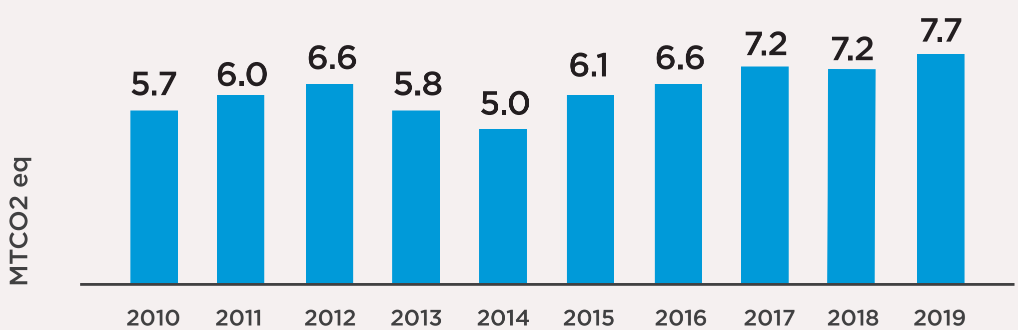
Subnational policies/measures

- Enhancing transportation capacity of Line I and Line II of the metro in Santo Domingo.
- Constructing monorail, Santiago de los Caballeros.
- Building Line II of the cable car and the first bicycle path in Great Santo Domingo.
- Renovating the fleet and technological upgrade, OMSA.
- Electric buses and replacement of collective taxis (conchos).

4.
Adoption of UNFCCC mechanisms

Mechanism	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**



+34%

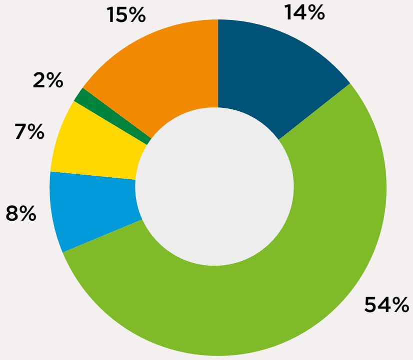
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Ecuador

1.
CO2 emissions derived from fuel combustion (2019)

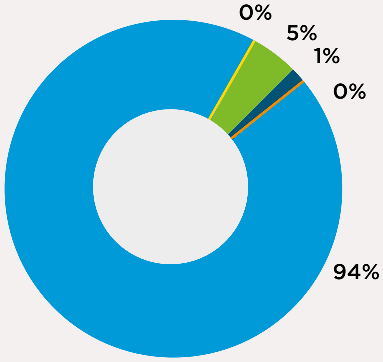
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

*__Note:__ According to INGEI (2015), the transportation sector emitted a total of 7,635.83 Gg of CO2, equivalent to 21.5%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

(●) YES ( ) NO

• Mitigation measures proposed in NDC

SHIFT — Measures aimed at modifying the mode of transportation

1. Efficient public transportation: boosting mass public transportation operated with electric energy (Metro in Quito, Tramway in Cuenca).

IMPROVE — Measures aimed at improving the efficiency of transportation systems

1. Transportation NAMA: freight and passenger.

Ecuador

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Electromobility Strategy.
- Energy Efficiency Law.
- Implementation Plan of Ecuador's First Nationally Determined Contribution 2020-2025 (PI-NDC) and transportation NAMA.
- Ordinance to encourage electric transportation
- Ecuador's Third National Communication.
- Ecuador's National Climate Change Strategy.
- National Transition Plan towards Decarbonization.

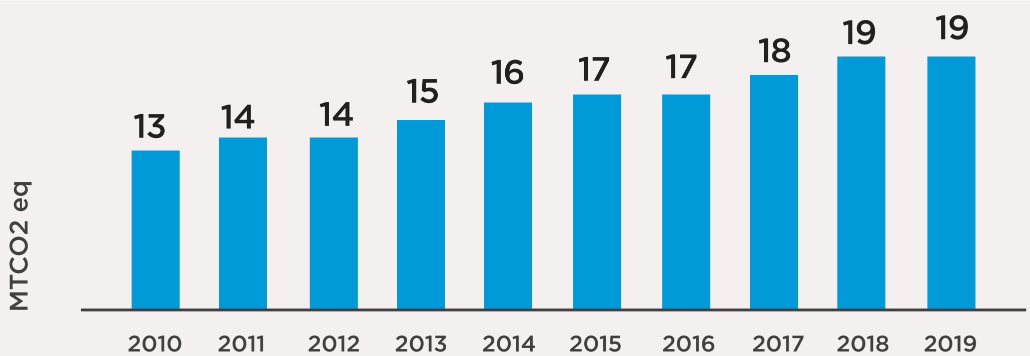
Subnational policies/measures

- Building and starting operation of the Quito Metro.
- Operating the Cuenca Tramway.
- Electrification of public transportation routes and taxis.
- Innovative land transportation system and sustainable mobility for the Galapagos Archipelago.
- Action plan to implement the Electromobility Strategy: Historic Center of Quito (HCQ).

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**



+54%

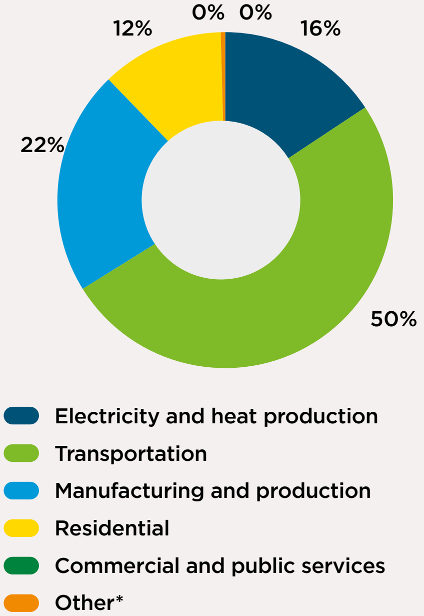
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

El Salvador

1.
CO2 emissions derived from fuel combustion (2019)

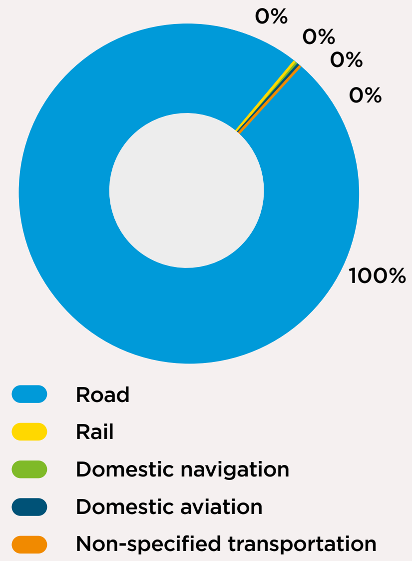
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2014), the transportation sector emitted a total of 2,801.9 K tonnes of CO2, equivalent to 14%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Mass public transportation, bicycle use, walking, restricted speed and traffic management zones, in consideration of road safety and the promotion of public spaces.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Introducing electromobility in the vehicle fleet with primary attention to passenger, public, and private transportation.

El Salvador

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Energy Policy 2020-2050.
- Climate change policies for the public works, transportation, housing, and urban development sectors 2018 -2036.

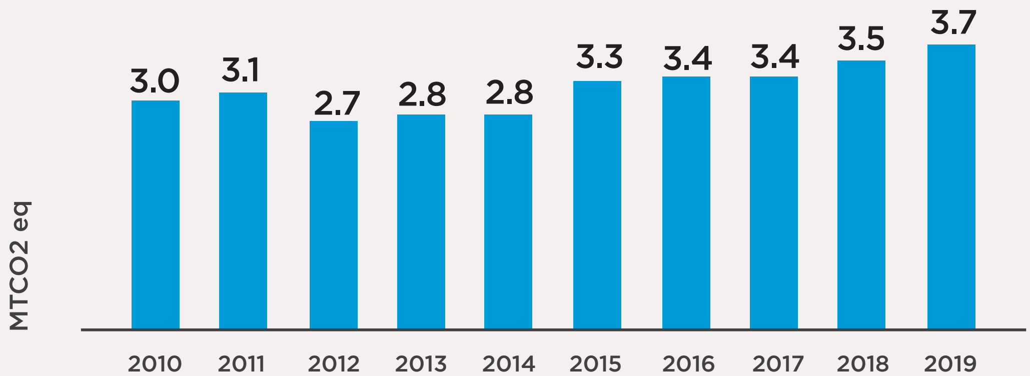
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	●
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**

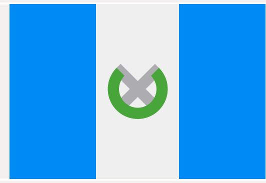


+24%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

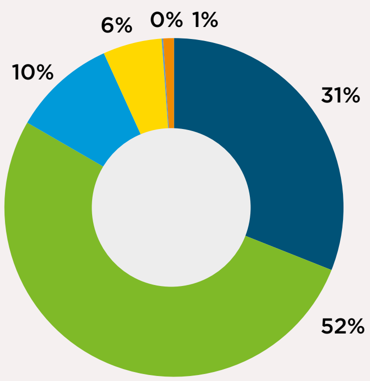
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Guatemala



1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

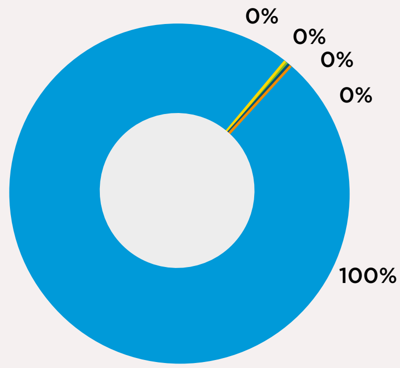


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2016), the transportation sector emitted a total of 9,234.1 k tonnes of CO2, equivalent to 48.15%

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

(●) YES ( ) NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Electromobility and biofuels (program to renovate the private vehicle fleet with more efficient alternatives and program to promote the use of advanced ethanol in gasoline).

Guatemala

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Low Emission Development Strategy.
- National Climate Change Plan.
- Law on Incentives for Electric Mobility (Decree No. 40-2022).
- Energy Policy 2019-2050.
- National Energy Plan (2017-2032).
- Energy Efficiency Plan (2017).

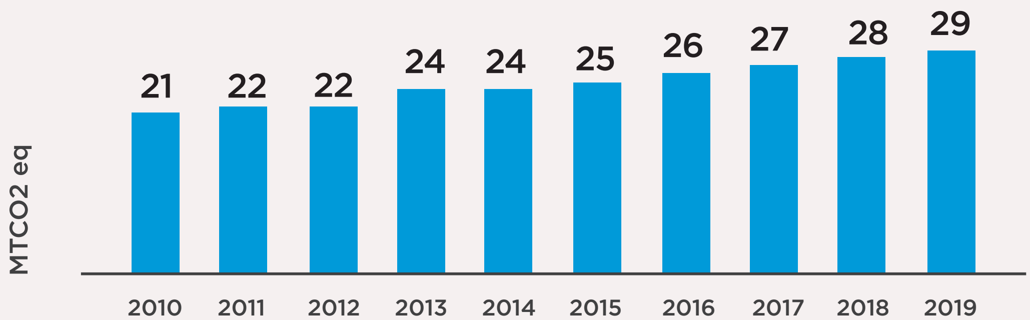
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	●	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	●	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**

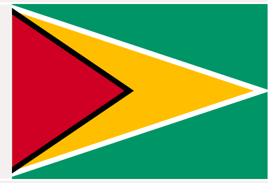


+62%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

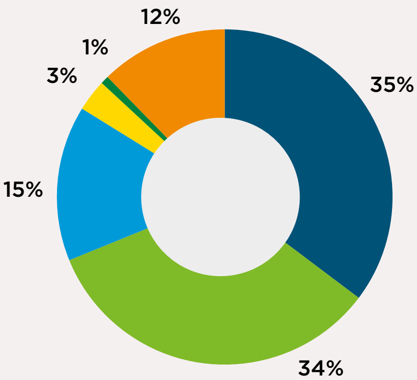
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Guyana



1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

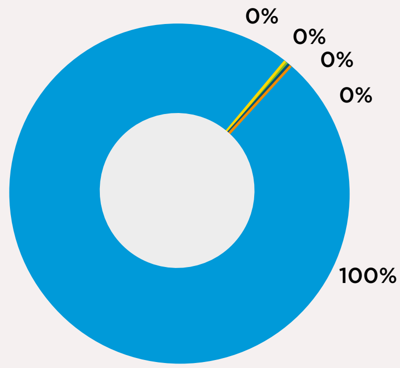


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), “GHG Emissions from fuel combustion (summary)”, IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

*__Note:__ According to Guyana’s Third National Communication to the UNFCCC (2021), the transportation sector emitted a total of 769 Gg of CO2.

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), “Detailed CO2 estimates”, IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

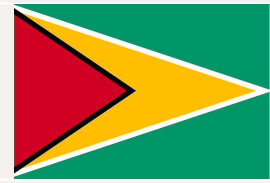
2.
Transportation sector is prioritized in NDC

○ YES ◉ NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Guyana



3.
Coherence of NDC measures with plans and policies

National policies/measures

- Third National Communication to the National Framework Convention on Climate Change (UNFCCC).
- Low Carbon Development Strategy 2030.

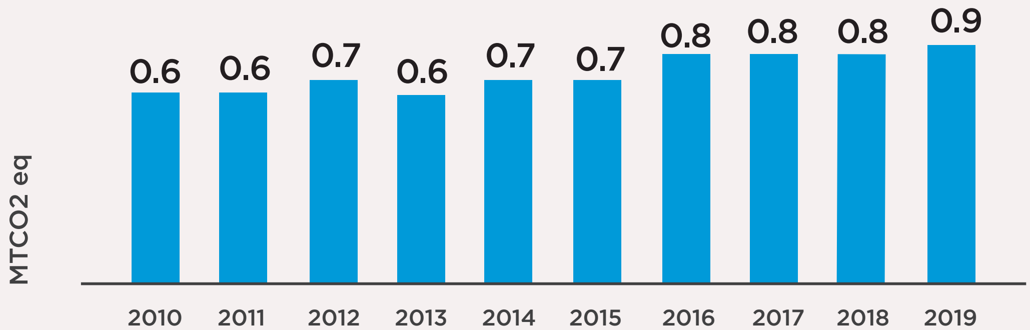
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

National Adaptation Plan sent to UNFCCC (NAP)	NO
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	NO
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	NO
National Adaptation Program of Action sent to UNFCCC (NAPA)	NO
NDC presented	YES
Transportation is prioritized in NDC	NO
Mitigation goals for transportation in NDC	NO

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**

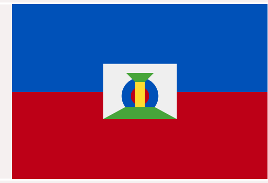


+46%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

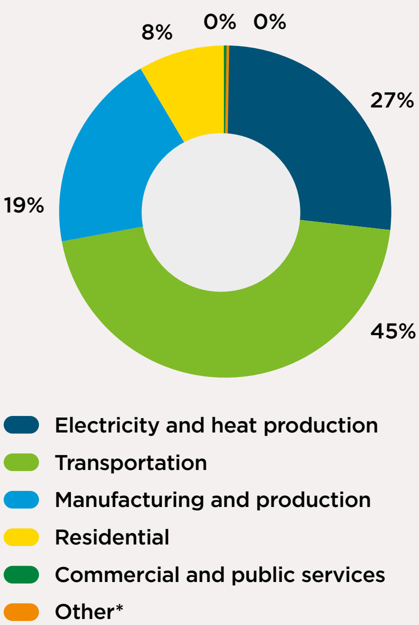
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Haiti



1.
CO2 emissions derived from fuel combustion (2019)

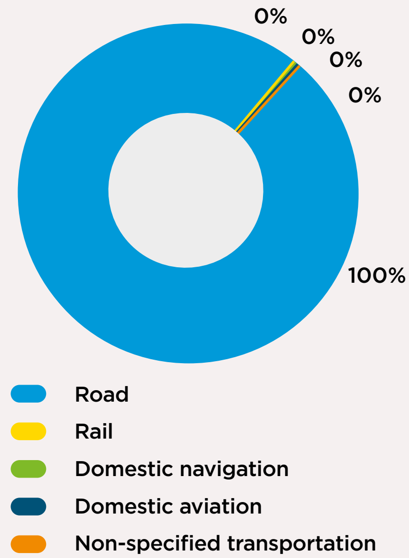
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2013), the energy sector emitted a total of 744,04 Gg tonnes of CO2, equivalent to 9.5%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

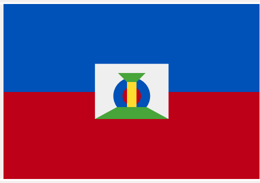
2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Improving motorcycle maintenance and use. **2.** Restricting used vehicle imports.

Haiti



3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Policy about Climate Change (PNCC, after its Spanish initials).

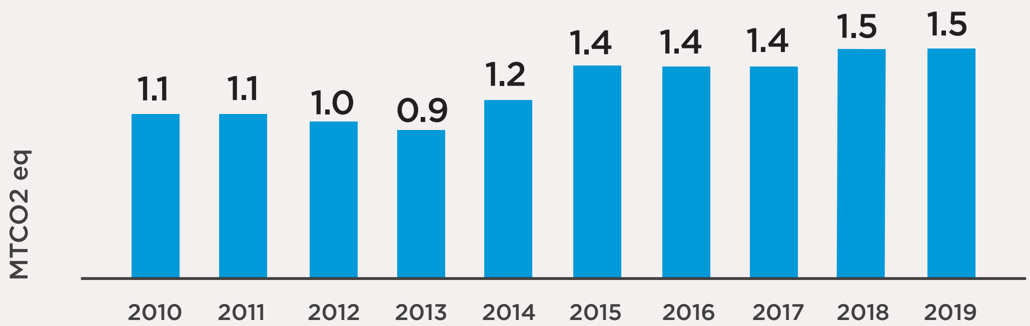
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)		●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)		●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)		●
National Adaptation Program of Action sent to UNFCCC (NAPA)	●	
NDC presented	●	
Transportation is prioritized in NDC	●	
Mitigation goals for transportation in NDC		●

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+36%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

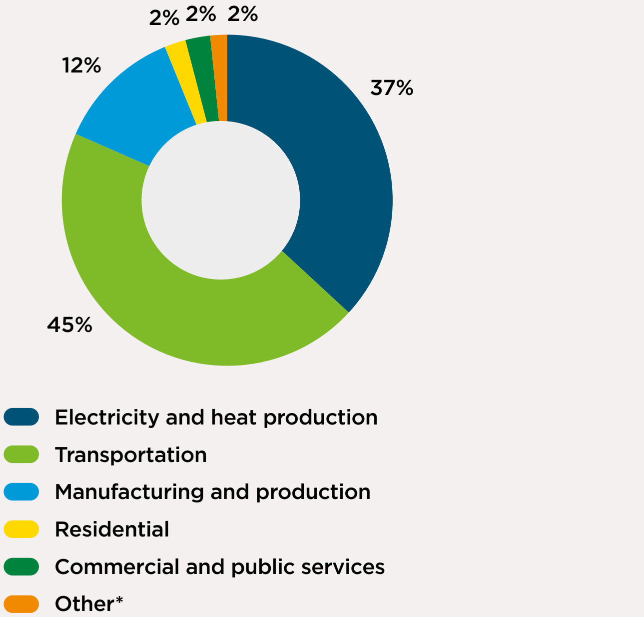
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Honduras

1.

CO2 emissions derived from fuel combustion (2019)

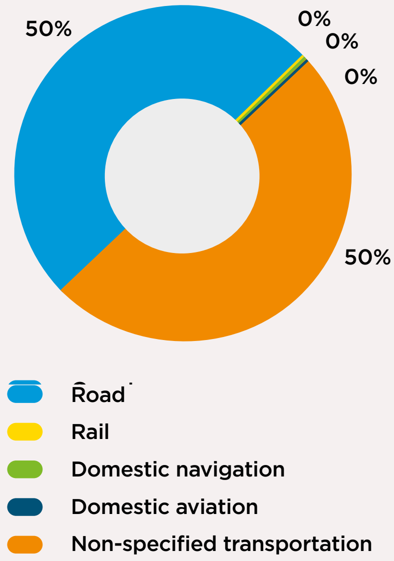
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to INGEI (2020), the transportation sector emitted a total of 3,500 Gg tonnes of CO2, equivalent to 29.9%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.

Transportation sector is prioritized in NDC

(●) YES ( ) NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Encouraging electromobility.

Honduras

3.
Coherence of NDC measures with plans and policies

National policies/measures

- Sustainable Energy Strategy 2030 of the Central American Integration System Nations (EES-SICA 2030).
- Promotion of Electromobility in Honduras.

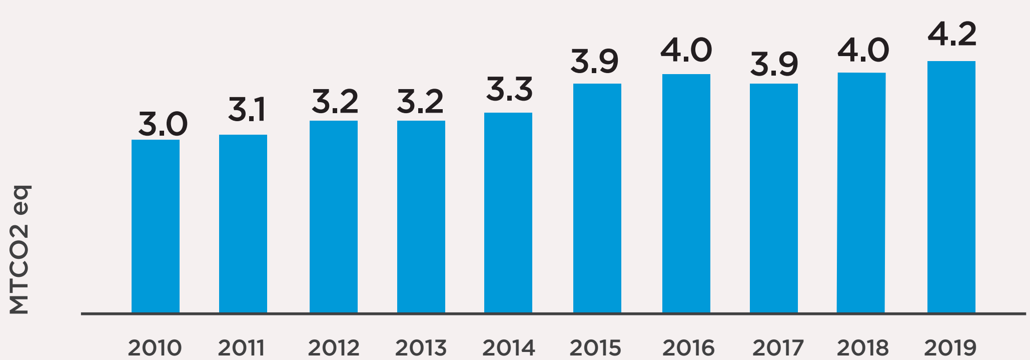
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**



+42%

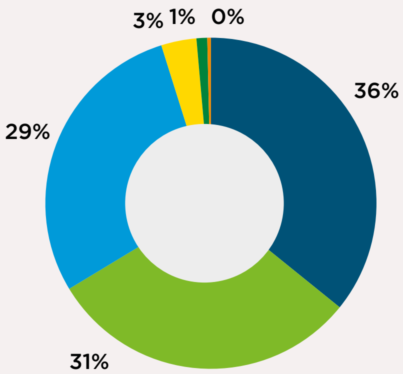
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Jamaica

1.
CO2 emissions derived from fuel combustion (2019)

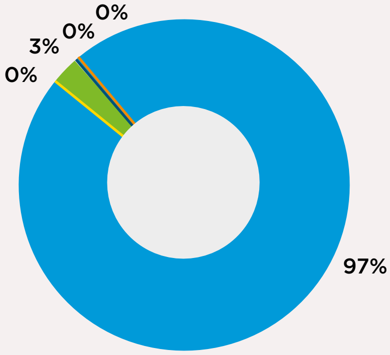
A. Emissions by sector



- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

○ YES ◉ NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Jamaica

3.
Coherence of NDC measures with plans and policies

National policies/measures

- Climate Change Policy Framework for Jamaica (2021).
- Vision 2030 Transport Sector Plan (2009).

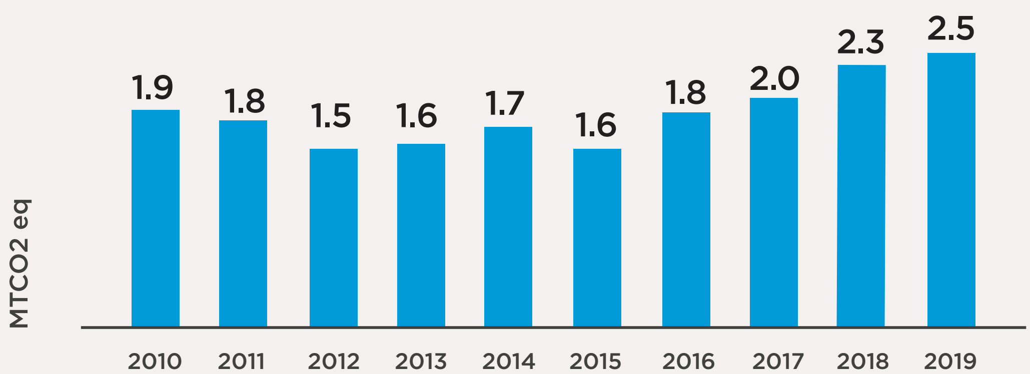
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	○	◉
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**

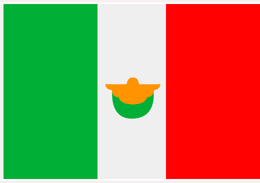


+33%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

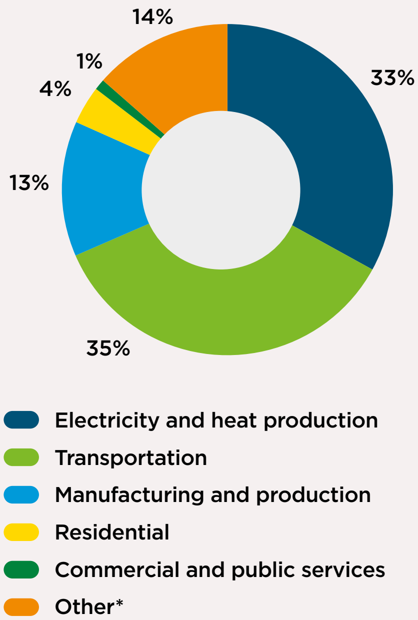
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Mexico



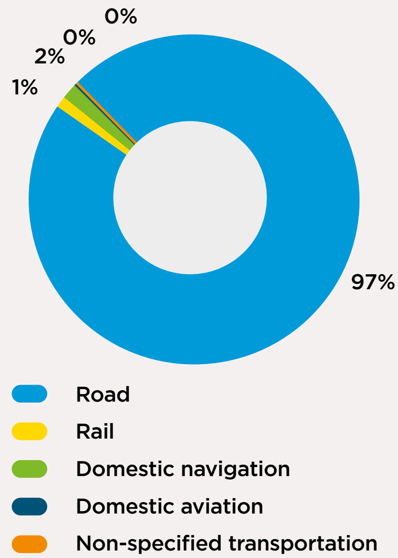
1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

Avoid	Measures aimed at reducing the demand for transportation	**1.** Encouraging remote work.
Shift	Measures aimed at modifying the mode of transportation	**1.** Expanding and rehabilitating the rail network.
Improve	Measures aimed at improving the efficiency of transportation systems	**1.** More efficient vehicles. **2.** Clean transportation programs.

Mexico

3.
Coherence of NDC measures with plans and policies

National policies/measures

- Alliance for Electromobility in Mexico: 2019- 2022.
- Climate Information System for Road Design (SICliC).
- National Electric mobility strategy.
- New National Strategy for Mobility and Road Safety (under development, to be published).
- National Public Transportation Policy (forthcoming).
- National Electric Mobility strategy (forthcoming).
- National Strategy for Mobility and Road Safety (forthcoming).
- National Policy for Collective Public Transportation (forthcoming).

Subnational policies/measures

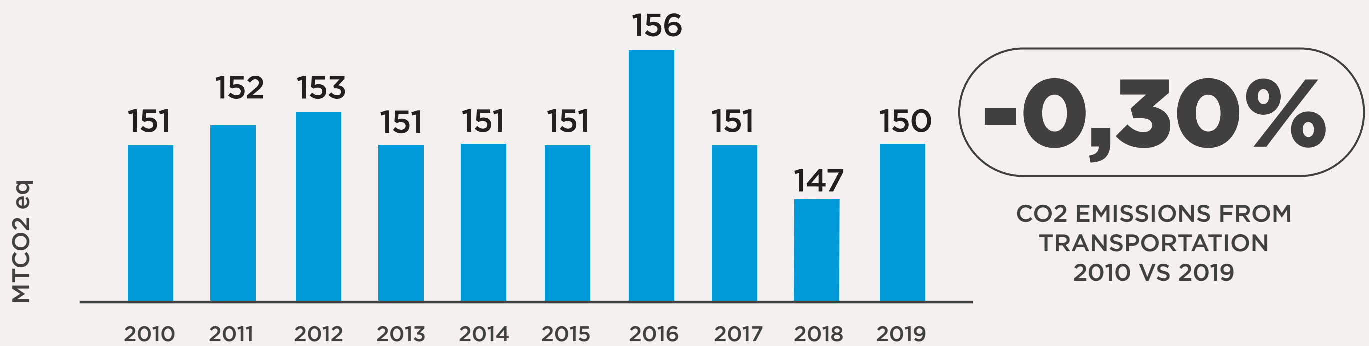
- Mexico City Climate Action Program: 2014 – 2022.
- Mexico City Zero Emission Corridors.
- ECOBICI Individual Transportation System.
- Rehabilitation of line 1 of the Mexico City subway.
- Construction of two cable car lines (cablebus).
- Replacement of the entire trolleybus fleet.

4.
Adoption of UNFCCC mechanisms

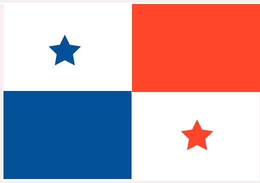
	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	◉	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	◉	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

Mexico

Evolution of CO_2 emissions from the transportation sector (2010-2019)



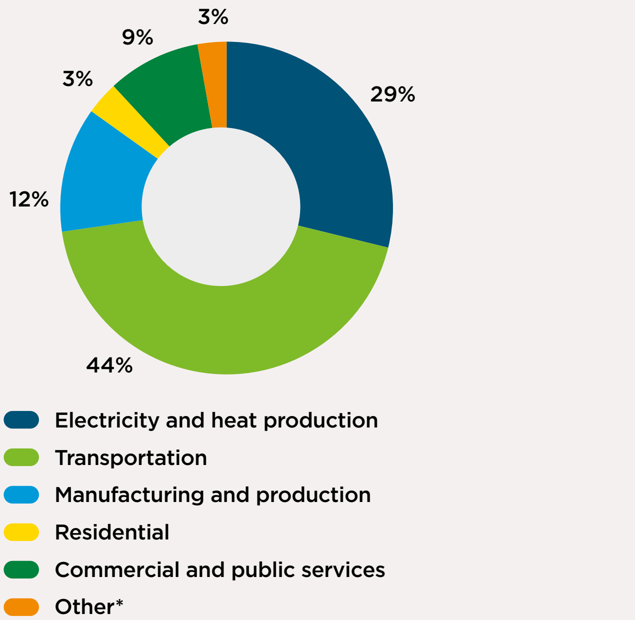
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en



Nicaragua

1.
CO2 emissions derived from fuel combustion (2019)

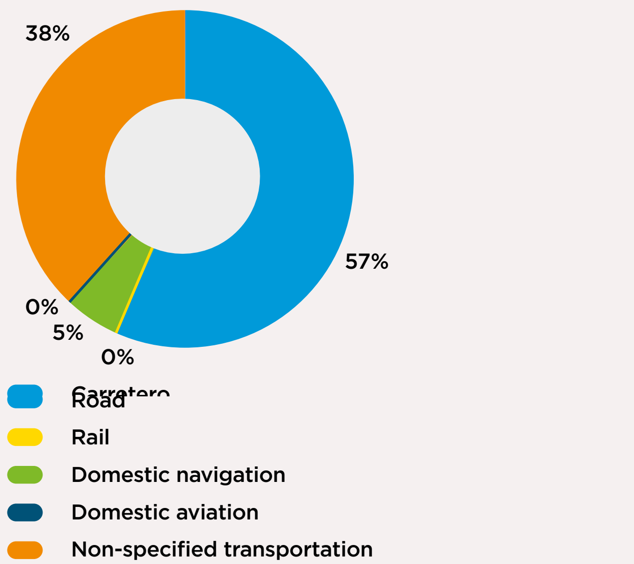
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

*Note: According to INGEI (2015), the transportation sector emitted a total of 2,973.89 Gg tonnes of CO2, equivalent to 6%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

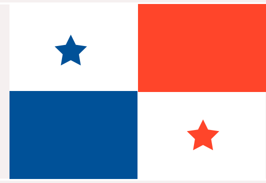
2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Improving the public transportation system of Metropolitan Managua.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Nicaragua



3.

Coherence of NDC measures with plans and policies

National policies/measures

- National Climate Change Policy.
- Electric Stability Law.

Subnational policies/measures

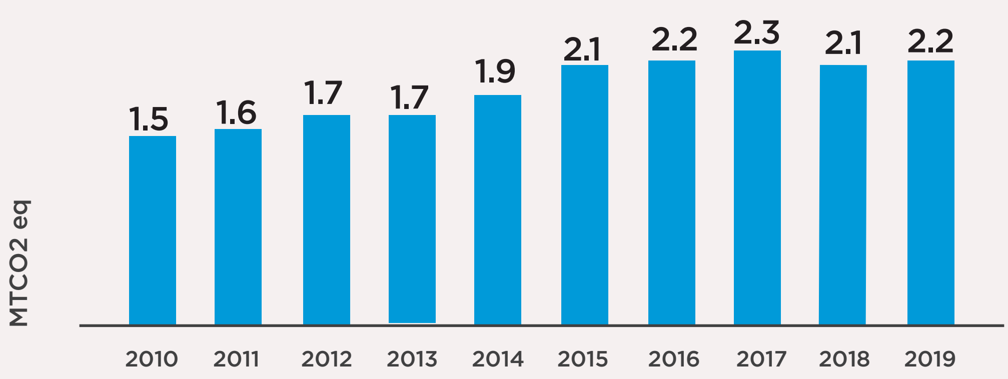
- Promoting Environmentally Sustainable Transportation in Metropolitan Managua (as part of the National Transportation Plan).

4.

Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)		●
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)		●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)		●
National Adaptation Program of Action sent to UNFCCC (NAPA)		●
NDC presented	●	
Transportation is prioritized in NDC	●	
Mitigation goals for transportation in NDC		●

- **Evolution of CO_2 emissions from the transportation sector (2010-2019)**

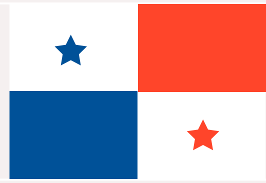


+39%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

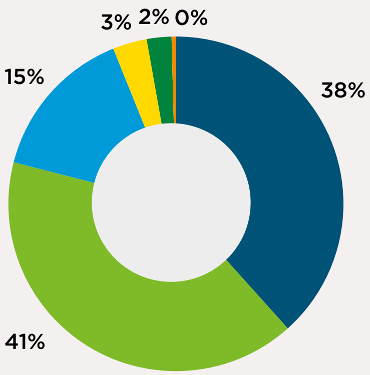
Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Panama



1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector

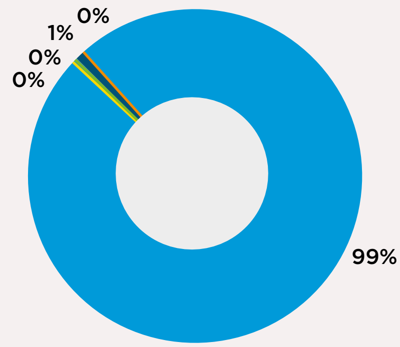


- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to CDN1 (2017), the transportation sector emitted a total of 6.36 M tonnes of CO2, equivalent to 56.8%.

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

(●) YES ( ) NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Panama

3.

Coherence of NDC measures with plans and policies

National policies/measures

- Electric Energy Transition Agenda.
- Electric Mobility strategy.

Subnational policies/measures

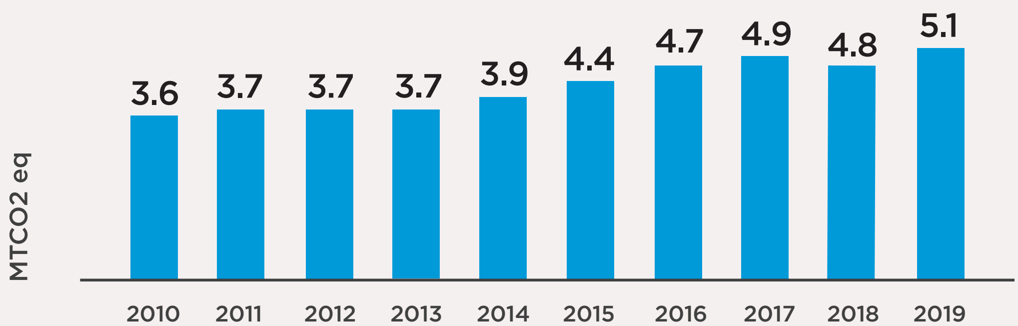
N/A

4.

Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+44%

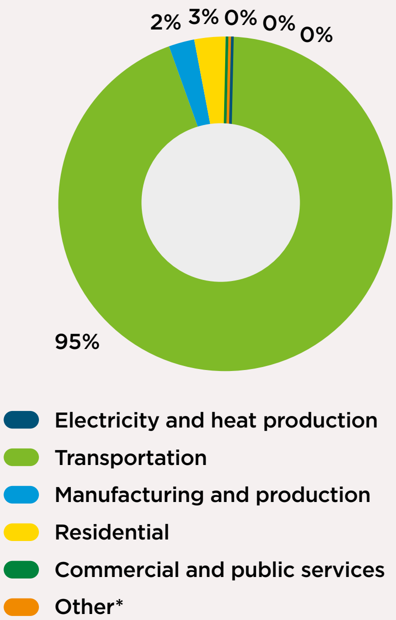
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Paraguay

1.
CO2 emissions derived from fuel combustion (2019)

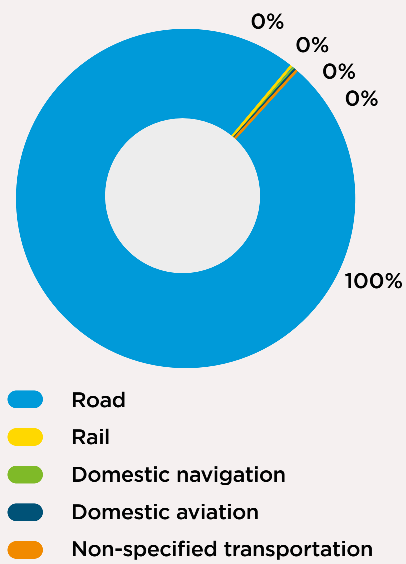
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to (MADES/PNUD/FMAM, 2019), the transportation sector emitted a total of 5,450.53 K tonnes of CO2, equivalent to 10.62%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

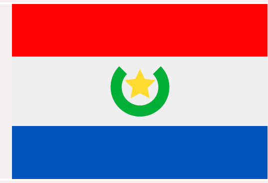
2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Increasing substitution of fossil fuels by biofuels (depending on the type of engine, up to 7.5% addition to diesel and 27.5% to gasoline). **2.** Efficient driving in public and freight transportation. **3.** Gradually substituting conventional vehicles with electric and hybrid vehicles. **4.** Employing green hydrogen.

Paraguay



3.

Coherence of NDC measures with plans and policies

National policies/measures

- Sectoral Climate Change Mitigation Plans.
- Energy Policy of the Republic of Paraguay.
- Electric Mobility Master Plan for Urban Public Transport and Logistics.
- Towards the green hydrogen route in Paraguay.
- Legal framework for the importation of electric vehicles.
- National Electric Mobility Strategy: 10%- 20% of the public transportation fleet should be electric, 300 public charging stations.

Subnational policies/measures

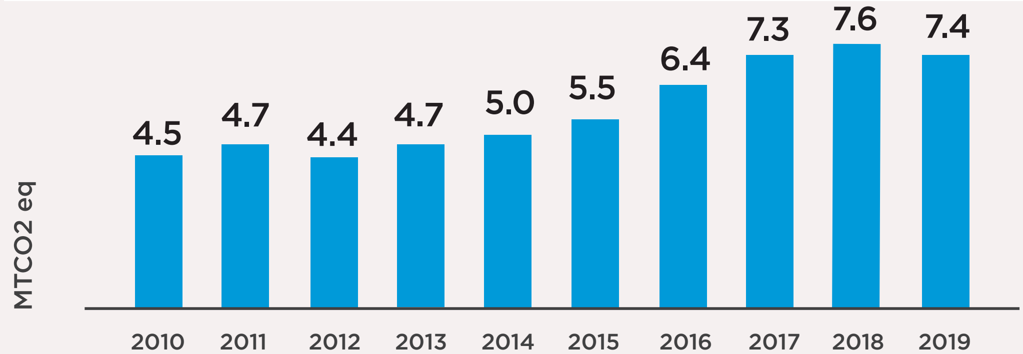
- Asuncion, Green City of the Americas - Pathways to sustainability.
- Construction and implementation of the green route to connect Asuncion and Ciudad del Este.
- Public transportation fleet renewal program in the Metropolitan Area of Asuncion.

4.

Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	◉	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+66%

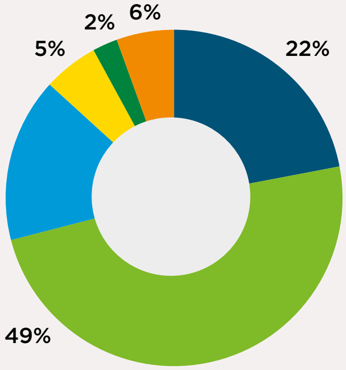
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Peru

1.
CO2 emissions derived from fuel combustion (2019)

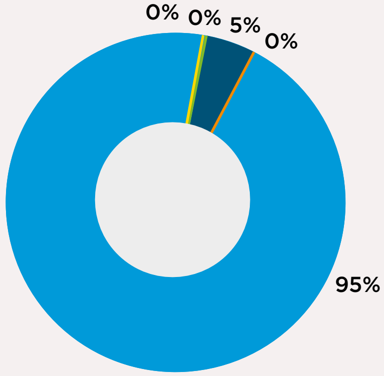
A. Emissions by sector



- Electricity and heat production
- Transportation
- Manufacturing and production
- Residential
- Commercial and public services
- Other*

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



- Road
- Rail
- Domestic navigation
- Domestic aviation
- Non-specified transportation

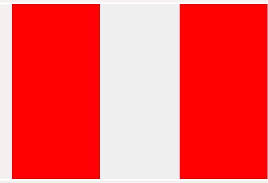
Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

○ YES ◉ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A



Peru

3.

Coherence of NDC measures with plans and policies

National policies/measures

- National Climate Change Adaptation Plan 2050.
- Framework Law on Climate Change.
- National Climate Change Strategy.
- Energy Transition Roadmap for an emissions-free Peru 2030-2050.

Subnational policies/measures

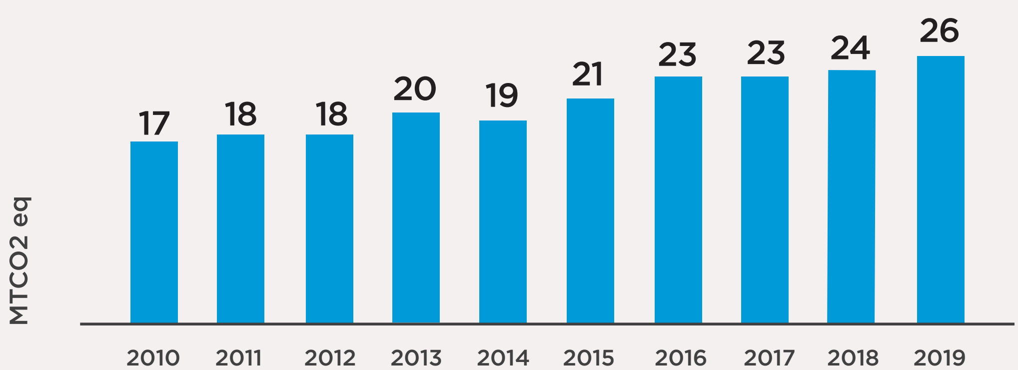
N/A

4.

Adoption of UNFCCC mechanisms

Mechanism	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	◉	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	◉	○
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	○	◉
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+51%

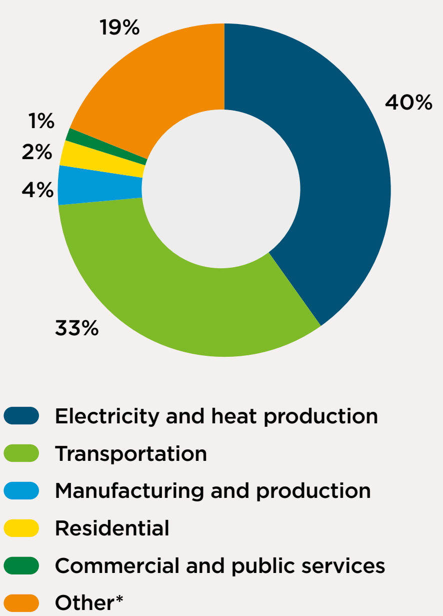
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Suriname

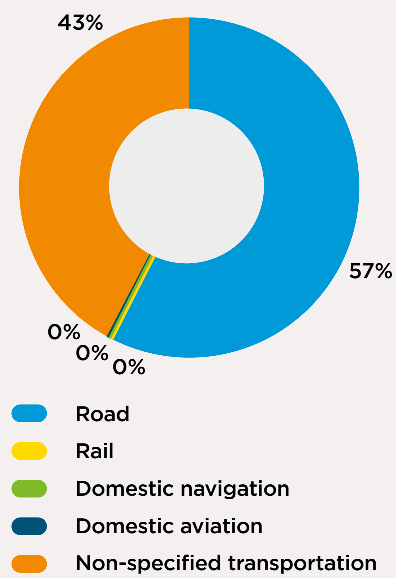
1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

• Mitigation measures proposed in NDC

SHIFT	Measures aimed at modifying the mode of transportation	**1.** Redesigning streets to make them more pedestrian friendly.
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Introducing vehicle emission controls by 2027 (public and private vehicles). **2.** Limiting imports of vehicles over 5 years old (public and private vehicles). **3.** Improving the public transportation system (adding segregated bus lanes, bus stations outside the city center, and shuttle buses within the city center).

Suriname

3.

Coherence of NDC measures with plans and policies

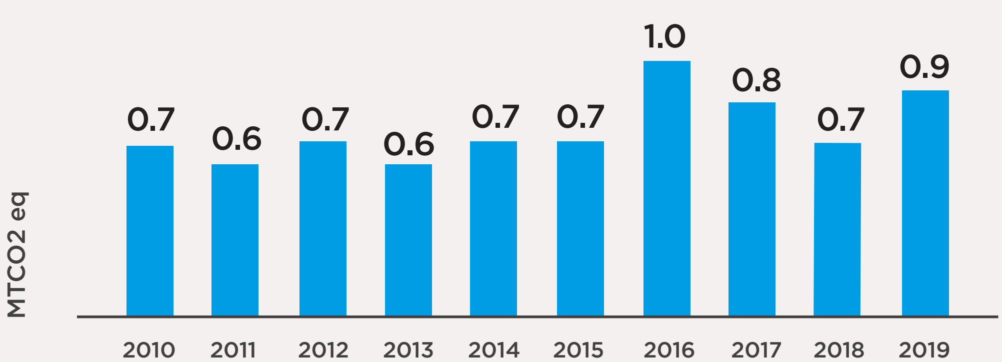
National policies/measures	Subnational policies/measures
N/A	N/A

4.

Adoption of UNFCCC mechanisms

Mechanism	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	◉	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	○	◉

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+31%

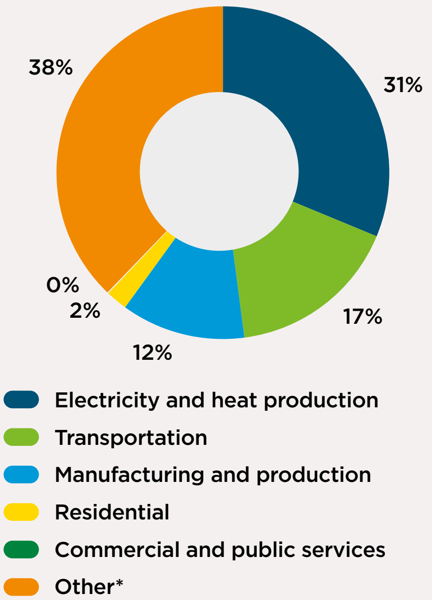
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Trinidad and Tobago

1. CO2 emissions derived from fuel combustion (2019)

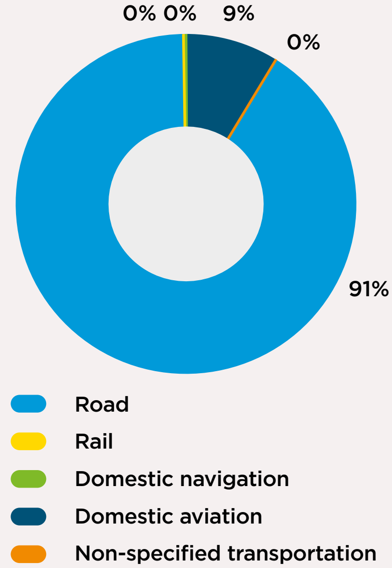
A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

***Note:** According to Trinidad and Tobago's First Biennial Update (2018), the transportation sector emitted a total of 2,688 Gg tonnes of CO2, equivalent to 6.4%.

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2. Transportation sector is prioritized in NDC

◉ YES ○ NO

By the year 2030, 1.7 MtCO2eq of reductions specifically in the public transportation sector.

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	N/A

Trinidad and Tobago

3.
Coherence of NDC measures with plans and policies

National policies/measures

- National Climate Change Policy (NCCP).
- Fuel Switching a state-funded program.
- Solar Park at Piarco International Airport (PIA).

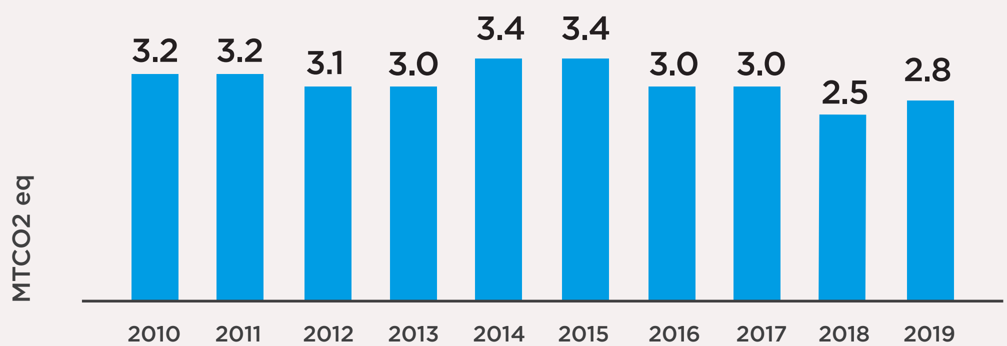
Subnational policies/measures

N/A

4.
Adoption of UNFCCC mechanisms

	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	○	◉
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	◉
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	○	◉
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	◉
NDC presented	◉	○
Transportation is prioritized in NDC	◉	○
Mitigation goals for transportation in NDC	◉	○

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



-14%

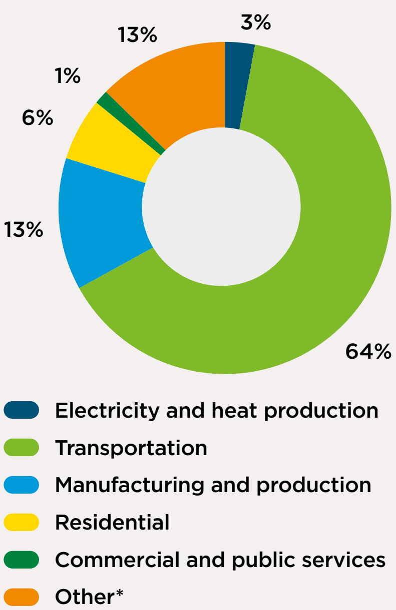
CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

Uruguay

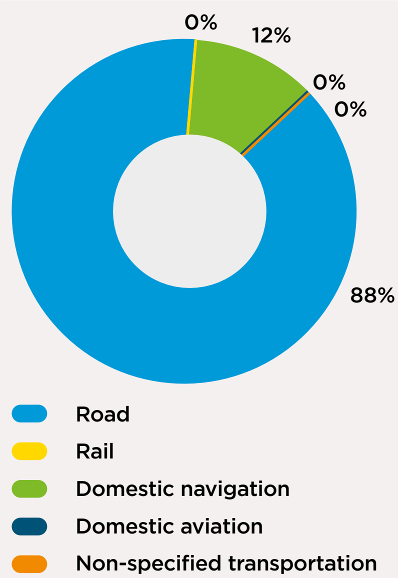
1.
CO2 emissions derived from fuel combustion (2019)

A. Emissions by sector



Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

B. Emissions by transportation mode



Source: IEA (2023), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/data-00429-en

2.
Transportation sector is prioritized in NDC

◉ YES ○ NO

- **Mitigation measures proposed in NDC**

SHIFT	Measures aimed at modifying the mode of transportation	N/A
IMPROVE	Measures aimed at improving the efficiency of transportation systems	**1.** Increasing the number of electric vehicles and fast and ultra-fast charging stations by 2030.

Uruguay

3.

Coherence of NDC measures with plans and policies

National policies/measures

- Sustainable Urban Mobility Project in Uruguay (NUMP).
- Electric Urban Mobility Guide.
- National Energy Efficiency Plan.

Subnational policies/measures

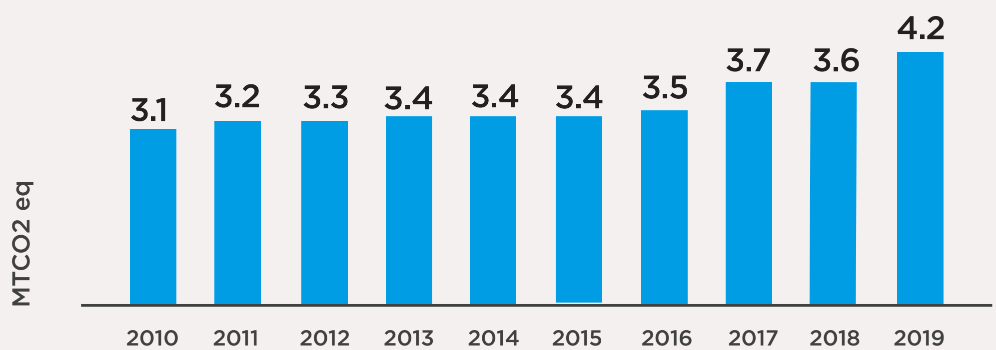
- *Montevideo* en bici
- Smart Bike Sharing System.

4.

Adoption of UNFCCC mechanisms

Mechanism	YES	NO
National Adaptation Plan sent to UNFCCC (NAP)	●	○
Nationally Appropriate Mitigation Actions presented to UNFCCC (NAMA)	○	●
Long-Term Low-Emission Development Strategy presented to UNFCCC (LT-LEDS)	●	○
National Adaptation Program of Action sent to UNFCCC (NAPA)	○	●
NDC presented	●	○
Transportation is prioritized in NDC	●	○
Mitigation goals for transportation in NDC	○	●

- **Evolution of CO2 emissions from the transportation sector (2010-2019)**



+35%

CO2 EMISSIONS FROM TRANSPORTATION 2010 VS 2019

Source: IEA (2023), "GHG Emissions from fuel combustion (summary)", IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database), https://doi.org/10.1787/445ec5dd-en

IDB