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Climate Change and IDB: Building Resilience and Reducing Emissions

Sector Study: Transport

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This evaluation is an input for the evaluation *Climate Change and the IDB: Building Resilience and Reducing Emissions.* It was conducted by Lynn Scholl, Margareth Celse-L'Hoste, Oscar Quintanilla, and Ana Maria Linares, with the consulting services of Juan Pablo Bocarejo and Ingrid Portilla, Grupo Sur, Universidad de los Andes. The authors are grateful to José Ignacio Sembler, Santiago Ramirez, and Miguel Soldano and Benoit Lefèvre (Embarq, World Resources Institute) for their valuable feedback.

ACRONYMS AND ABBREVIATIONS

BRT	Bus rapid transit system
CC	Climate change
CDM	Clean Development Mechanism
CNG	Compressed natural gas
CTF	Clean Technology Fund
CO	Carbon monoxide
CO_2	Carbon dioxide
ESG	Environmental and Safeguards Unit
GCI-9	Ninth General Capital Increase of the IDB
GEF	Global Environmental Facility
GHG	Greenhouse gas
HDV	Heavy-duty vehicle
IDB	Inter-American Development Bank
LAC	Latin America and the Caribbean
LDV	Light-duty vehicle
NO_x	Nitrous oxides
SO_x	Sulfur oxides
TC	Technical cooperation

PREFACE

Climate change (CC) poses important risks to development in Latin America and the Caribbean (LAC). Climate adaptation can limit the negative impacts and is important in achieving sustainable development and equity, including poverty reduction and economic growth. Integrating CC mitigation into development work is also an opportunity to foster and support the design and implementation of sustainable projects, programs and policies. Low-carbon alternatives contribute to more sustainable development. LAC countries are increasingly incorporating CC in their national policy agendas and aim to reduce GHG emissions and build climate resilience and the IDB has supported these efforts in the Region.

In 2013-2014, the Office of Evaluation and Oversight (OVE) carried out an evaluation of IDB's support for CC mitigation and adaptation (RE-459). This is OVE's first evaluation of IDB's interventions and institutional set-up related to CC. The evaluation seeks to document and to draw lessons from the recent IDB experience related to CC (2004-2014). It focuses on IDB-financed operations in important climate-related sectors—agriculture and natural resources, energy, disaster risk management, and transport—that directly support climate resilience-building (adaptation) or GHG emissions reduction (mitigation) or that have these outcomes as co-benefits. A number of background papers were produced for the evaluation and this is paper is one commissioned by OVE to support the overall CC evaluation.

EXECUTIVE SUMMARY

Transport is simultaneously a critical component of economic development, linking people with goods and services, and the source of such negative externalities as traffic congestion, accidents, and air and noise pollution. While most investments in infrastructure for transport are aimed at reducing transportation costs, facilitating trade, and improving the reliability and efficiency of networks, incorporating the goals of climate change mitigation and adaptation through a sustainable transport approach can generate several important co-benefits: improvements in air quality, traffic safety, and increased mobility and access to goods and services for all income groups, but particularly for lower-income groups, who are more dependent upon public transport, walking, and biking.

Additionally, building transport infrastructure that is more resilient to climate change (CC) may lead to increased economic returns on investments. Given that that the benefits of integrating CC mitigation strategies into projects have local costs but global benefits, such co-benefits can help make projects economically viable for countries facing key trade-offs in the allocation of scarce financial resources. Therefore, effectively and efficiently mainstreaming both CC mitigation and adaption strategies is critical to ensuring a sustainable economic development path that generates not only global but important local benefits to Latin American and Caribbean (LAC) populations, which will be increasingly resilient to the effects of CC in the Region.

Global greenhouse gas (GHG) emissions from transport have more than doubled since 1970; they are the fastest-growing source of energy-related emissions globally as well as in LAC). In 2011, transport emissions in LAC accounted for 35% of all energy-related CO_2 emissions in the Region, compared to a world average of close to 20%. On a per capita basis, emissions from transport in the Region increased by 12% between 2000 and 2009, while increasing less than 2% globally. Although per capita emissions in LAC are still low relative to those in developed countries, transport emissions in Europe and the United States are stabilizing or beginning to decline, while in LAC they continue to grow rapidly (IEA, 2013b).

This evaluation assesses how the Inter-American Development Bank (IDB, or the Bank) has addressed CC through its interventions in the transport sector in LAC between 2004 and 2013. It reviews progress made in the transport sector in response to the Bank's CC commitments in the Climate Change Strategy and other policy documents. It also examines the CC relevance and results of a sample of 20 projects for land transport.

The Bank's focus on CC, in terms of the share of transport operations with explicit[1] mitigation or adaptation objectives, has increased over time: between 2008 and 2013 the Bank approved 12 such loans (compared with none prior to 2008), 10% of its transport operations for this period. These loans tended to focus on public transport investments in urban areas (61% of explicit CC

[1] *Explicit CC projects* were defined as those that include among their objectives reducing GHG emissions or enhancing the resilience of transport infrastructures and services.

loan amounts), and logistics (33% of explicit CC loan amounts), with a small share of lending (6%) for adaptation (roads projects).

OVE also identified the lending portfolio of projects with an implicit[2] CC objective—that is, projects that could have indirect CC co-benefits. These implicit CC loans made up 23% of the portfolio (29 loans); 70% were for public transport in urban areas, with the remainder for logistics (7%), roads with an adaptation component (21%), and water-based transport (3%).

In total, then, between 2004 and 2013 the Bank approved 41 CC-related loans (implicit plus explicit), summing to around US$3.99 billion, or 27% of lending for transport during the period. While public transportation (such as Bus Rapid Transit (BRT) systems and metros) accounts for the lion's share of CC-related loans, much of the growth in CC-related projects came from increases in the number of logistics, multimodal integration, and road projects with one or more adaptation components.

Climate change was a more dominant theme in technical cooperation (TC) than in lending: nearly 50% of the TCs approved over the period were related to CC. Of these, most (92%) were focused on mitigation rather than adaptation. Both the number and diversity in the types of CC-related TCs have increased over time. These TCs are used not only for project preparation, but also to support institutional strengthening, generate knowledge and methods relevant to CC, facilitate the participation of the private sector, and facilitate projects' eligibility to receive climate finance.

At the policy level, at the Rio+20 conference in 2012 the Bank committed to lend $1.75 billion for sustainable transport in the next 10 years. However, while the Bank recognized the importance of promoting sustainable low-carbon transportation solutions for passengers and freight in both urban and rural settings (Climate Change Strategy, Infrastructure Strategy, Transportation Sector Framework), it has yet to define a clear policy with respect to measuring and mitigating GHG emissions from the transport sector. The Bank estimates ex ante emissions in projects with a high potential of generating GHGs (such as transport projects), but such estimates do not take into account the full operation of the infrastructure over the life of the project, inform project design, or trigger the requirement for analyses of lower-carbon or more sustainable alternatives to achieve the same development objectives.

At the project level, the evaluation found the following:

a. Weaknesses in the analytic basis of CC-related transport projects (with explicit and implicit CC objectives), both in the completeness of their diagnostics and in the soundness of their results matrices and monitoring and reporting mechanisms.

b. Important emission reductions in the four urban mass transportation projects for which emissions benefits were estimated (two metro lines and two BRTs). For the BRT projects, restructuring of routes resulted in fewer bus kilometers traveled to serve the same number of

[2] *Implicit CC projects* are projects whose objectives do not explicitly include addressing CC mitigation but for which the literature and the empirical evidence indicate that the type of intervention can reduce GHG emissions. The loan proposal may recognize CC mitigation as a co-benefit.

trips. However, several issues—including slow construction, difficulty in decommissioning obsolete polluting buses, and financial difficulties of the bus operators—have affected the capacity of the systems to fully meet mobility needs, and, the extent of emissions reductions resulting from the system.

c. The roads projects for which emissions were estimated (São Paulo beltway Oeste and Norte, and two interurban roads) showed significant short-term reductions in emissions relative to the business-as-usual scenario. When vehicle congestion levels are high, projects that increase the road network's capacity, such as the São Paulo metropolitan beltway, can improve driving conditions and shorten travel distances for a significant number of private vehicles and freight carriers. However, the medium- and long-term effects of these projects are not so clear. Planners tend to underestimate the induced traffic from these improvements, and to overestimate how long this additional capacity will be able to maintain service levels. Therefore, potential rebound effects need to be considered.

d. Few projects with explicit adaptation objectives have been approved since 2008; the Bank's action in the field of adaptation to climate change is still in its infancy and therefore difficult to assess. There are data limitations in the diagnostics and in the definition of the proposed interventions; in addition, when project monitoring systems included adaptation indicators, they usually lacked specificity and baselines.

For the Bank to fully implement its vision in the transport sector, OVE makes the following suggestions:

a. Develop policy guidelines with respect to CO_2 and other GHG emissions from transport projects, with the following requirements: (i) for all projects, estimate emissions ex ante against a business-as-usual scenario for the 20-year life of the project, using an improved methodology that takes into account all stages of project design and implementation; and (ii) for projects with significant emissions, consider lower-carbon alternatives to achieve development objectives or incorporate mitigation and/or compensation measures into project design. This policy should consider highlighting the importance of taking a system wide approach to analyzing the potential impacts of projects on GHG emissions and of tracking and monitoring progress on emissions reductions during and after project execution.[3]

b. Strengthen the analysis underlying CC-related projects by including sufficient data and information to clearly identify the mitigation or adaptation problems to be addressed, establishing a baseline to track progress, and including systematic monitoring and reporting mechanisms to measure progress and results.

3 For potential guidelines on measuring emissions, see WRI's GHG Mitigation Standards: http://www.ghgprotocol.org/files/ghgp/GHG%20Protocol%20Mitigation%20Goals%20Standard%20-%20Draft%20for%20Review%20Group%20-%20November%202012.pdf.

c. Strengthen the design of CC-related projects by systematically incorporating policy dialogue with client governments around potential complementary or "demand-side" measures or strategies to support infrastructure solutions.[4]

d. Strengthen Bank action on adaptation by adopting an intervention model that describes the continuum of possible interventions according to the "risk assessment – infrastructure protection/strengthening – alternate route creation" framework, and develop a set of core indicators for proper diagnostics and efficient monitoring and reporting of results.

4 Such demand-side measures include promoting transit-oriented development, travel demand management, and transport pricing.

I. INTRODUCTION

1.1 This evaluation assesses how the Inter-American Development Bank (IDB, or the Bank) has addressed climate change (CC) through its interventions in the transport sector between 2004 and 2013. Transport represents an important share of the Bank's work: roughly 17% of total Bank lending financed transport projects between 2004 and 2013.[1] Moreover, transport is both a critical component for economic development, linking people with goods and services, and the source of such negative externalities as traffic congestion, accidents, and air and noise pollution. While most investments in transport infrastructure aim to reduce transportation costs, facilitate trade, and improve the reliability and efficiency of networks, incorporating the goals of CC mitigation and adaptation through a sustainable transport approach can generate several important co-benefits.[2] Additionally, building transport infrastructure that is more resilient to CC may lead to increased economic returns on investments. Global greenhouse gas (GHG) emissions from transport have more than doubled since 1970; they are the fastest-growing source of energy-related emissions globally as well as in Latin America and the Caribbean (LAC). In 2011, transport emissions in LAC accounted for 35% of all energy-related CO_2 emissions in the Region, compared to a world average of close to 20% (IEA 2013b). On a per capita basis, emissions from transport in the Region increased by 12% between 2000 and 2009, while increasing less than 2% globally.

1.2 In addition, the transport sector in LAC is highly vulnerable to the effects of CC on the integrity of its infrastructure and the reliability of movement of goods and people within its network. The risks associated with CC can include damages to transport infrastructure from storm surges and sea level rise in coastal areas, as well as reduced access and service reliability in transport corridors following extreme climate events.[3]

1.3 This document is organized into five chapters. Following this introduction, Chapter II outlines the main CC issues of the transport sector. Chapter III analyzes the evolution of the Bank's CC-related transport portfolio over the last 10 years and the Bank's response to its CC commitments. Chapter IV assesses the relevance, implementation, and results of a sample of 20 projects. Chapter V presents the conclusions of the study and suggestions for the Bank to further the work already started and fully implement its vision of mainstreaming CC in its transport operations.

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1 IDB lending to the transport sector rose from US$515 million in 2004 to US$2.364 million in 2013.

2 These benefits include improvements in air quality, traffic safety, and increased mobility and access to goods and services.

3 For example, floods and landslides from intense rains can block goods movement or disrupt people's access to critical goods and services, such as medical care, education centers, food and water, and employment. Higher temperatures in public transport systems and along roadways (which have higher temperatures, particularly for roads paved with black asphalt, than surrounding vegetated areas) can lead to adverse health impacts for transport infrastructure users and pavement failures on critical road links, such as cracking and pavement bursts that may cause large disruptions in the flow of goods and passengers, as well as traffic accidents.

II. CLIMATE CHANGE AND THE TRANSPORT SECTOR

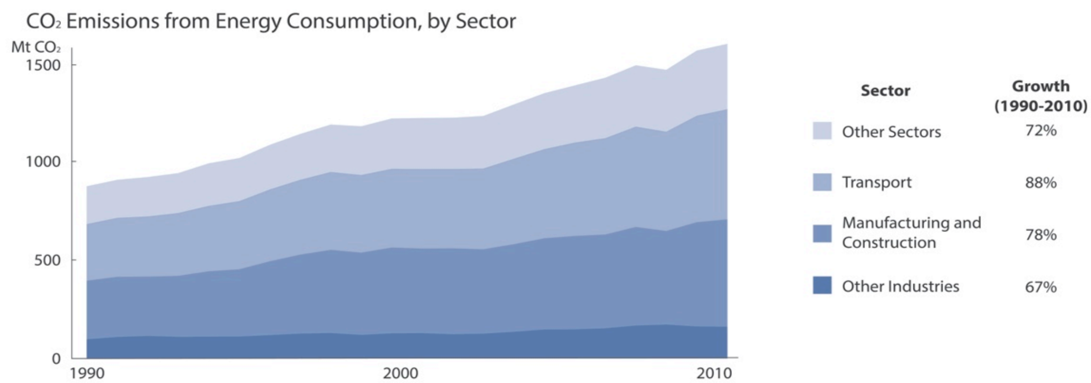
A. Mitigation of GHG emissions

2.1 Global transportation emissions have more than doubled in the past four decades, representing roughly 21% of energy-related emissions worldwide (WRI, 2014).[8] Given current trends, the International Energy Agency estimates that transport emissions worldwide will grow by 80% by the year 2050 (IEA, 2009).

2.2 LAC contributes approximately 9% of the global transport sector emissions (WRI, 2014). Per capita, LAC emissions are less than one-fifth those in North America, but they exceed the world average.[9] On a GDP basis they also exceed the world average,[10] and they rank fifth globally on a GDP basis by region. Although per capita emissions in LAC are still low relative to those of developed countries, transport emissions in Europe and the United States are stabilizing or beginning to decline, while those in LAC continue to grow rapidly (IEA, 2013b).

2.3 Within LAC, emissions generated by transportation activities are the largest source of energy-related emissions (35%, compared to 29% for electricity and heat and 21% for manufacturing and construction) (IEA, 2013b). They are also the fastest-growing source of energy-related emissions, more than doubling from 1980 to 2005[11] and growing faster than any other energy sector in LAC between 1990 and 2010 (see Figure 2.1)

Figure 2.1. Growth in emissions due to energy consumption in LAC, 1990-2010



Source: IEA, 2013b.

8 Of this increase, 80% has come from road vehicles for both passenger and freight transport (IPCC, 2014), with OECD countries dominating global transportation sector emissions (3.14 $GtCO_2e$/year, 2010) and the share of Asian countries growing rapidly (IPCC, 2014).

9 Per capita emissions: LAC—0.92 tCO_2; North America—5.22 tCO_2; world average—0.84 tCO_2.

10 LAC 73.57 versus world 64.7 tCO_2/$million GDP (WRI, 2014).

11 From 251 Mt in 1980 to 453 in 2005 (WRI, 2014).

2.4 Road transport is the main source of CO_2 emissions[12] in the transportation sector worldwide, accounting for 74% of total emissions, of which 61% are due to passenger transport and the remainder to freight. In LAC, because of the lower energy efficiency of transport systems, a full 93% of emissions are from road transportation emissions, of which about 50% come from passenger transport and 50% from freight (IEA, 2013a; DeCicco, 2013). In urban areas the main contributor is the transport of passengers, including light-duty vehicles, followed by light- and medium-duty trucks, while in intercity transport the main contributor is the transportation of cargo through heavy- and medium-duty trucks (Schipper, 2010).

2.5 Emissions in LAC are highly heterogeneous. Trinidad and Tobago, Venezuela, and Mexico have the highest per capita levels (2.13, 1.45, and 1.27 tons CO_2 per capita, respectively), while Haiti, Nicaragua, and Guatemala have the lowest levels (0.28, 0.12, and 0.28 tons CO_2 per capita, respectively) (WRI, 2014). These differences reflect such factors as fuel subsidies, income levels, economic activity, levels of motorization, levels of traffic congestion, and average age of the vehicle fleet.

2.6 In absolute terms, Brazil contributes 33% of total LAC transport emissions, followed by Mexico with 28%. If Argentina and Venezuela are added, these four countries account for 78% of transport emissions in the Region. Ecuador, Bolivia, Paraguay, Jamaica, and Honduras have the highest emissions per GDP (110-91 tCO_2/$ million GDP).

1. Drivers of emissions from the transport sector

2.7 For the most part, GHG emissions from transport pose a global rather than a local problem.[13] At the local level, the problems that LAC countries face include high levels of air pollution,[14] debilitating levels of congestion (the average commute can take two hours in some cities), high levels of traffic fatalities, and deteriorating and insufficient infrastructure (IPCC, 2014). These issues, in turn, are driven by such factors as high rates of urbanization, increasing urban sprawl, increasing motorization rates (driven by rising incomes), population growth, a shift in modal shares away from mass transit toward individual motorized modes, an aging vehicle fleet,[15] and an oversupply of old and polluting public transport vehicles (due to almost total deregulation of the transport sector during the 1980s and '90s in many LAC countries), combined with insufficient

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12 Because GHG emissions from transport consist primarily of CO_2, this report examines mainly CO_2. However, short-lived climate pollutants such as black carbon (associated with particulate matter from fossil fuel combustion), methane, volatile organic compounds, sulfur oxide (SO_x), and nitrous oxide (NO_x) have potent GHG effects and are gaining increased attention from policymakers.

13 See ICCT, 2013: http://www.theicct.org/sites/default/files/publications/ICCT_HealthClimate Roadmap_2013_revised.pdf

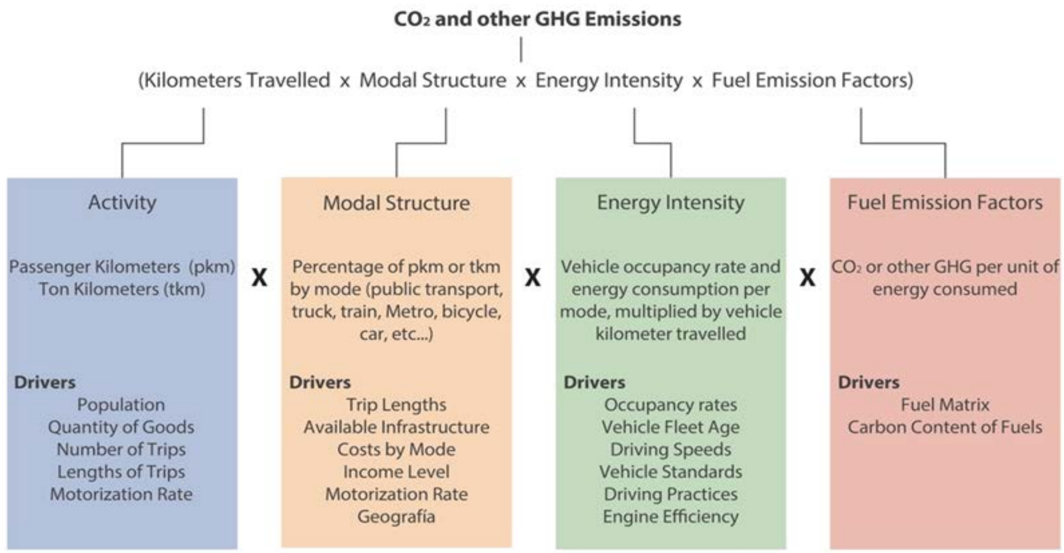
14 A recent study of five Latin American cities found a significant increase in cardiopulmonary and respiratory diseases associated with elevated levels of particulate matter of 10 micrograms and less in size (PM_{10}) and ozone (O_3) (Romieu et al., 2012). In addition, air pollution has been found to lead to a significant number of premature deaths each year, with at least 100 million people in LAC exposed to air pollution above World Health Organization standards.

15 An aging vehicle fleet is due in part to the importation of used and polluting vehicles from developed countries (UNEP, 2012).

investment and planning at the metropolitan level to sustainably meet the growing pressures these factors place on transport systems.

2.8 For analytic purposes, CO_2 emissions can be decomposed into four components (Figure 2.2): (i) activity level (passenger or ton-kilometers traveled), (ii) modal composition of travel, (iii) energy intensity of vehicles and transport systems, and (iv) the carbon content of fuels[16] (Schipper, 2009).

Figure 2.2. Relationship between transport and CO2 emissions



Source: Adapted from Schipper et al., 1999.

2.9 Growing emissions of CO_2 from transport have been driven primarily by growth in activity resulting from rising GDP and incomes,[17] population growth and demographic changes, and accompanying motorization and urban sprawl (IPCC, 2014; Schipper et al., 2009).[18] Urban dwellers in LAC have grown from 50% of the population in 1960 to about 80% in 2013 (United Nations, 2014). The growth of urban populations has also caused cities to expand, increasing the distances between origins and destinations and the energy required for trips, and fostering an increased demand for private motor vehicles to reach ever more dispersed urban locations.

16 CO_2 emissions per unit of energy are determined by the carbon content of the fuel and its calorific value.

17 Timilsina and Shrestha (2008) found that between 1980 and 2005, economic activity (growth in GDP) has been the primary factor driving emissions growth in some LAC countries—Argentina, Brazil, Costa Rica, Peru, and Uruguay. In other countries, decline in the energy efficiency of transport has been the main contributing factor: Bolivia, Caribbean, Cuba, Ecuador, Guatemala, Honduras, Panama, and Paraguay. In Chile, Colombia, El Salvador, Mexico, Nicaragua, and Venezuela, both activity and increasing energy intensity were the main factors.

18 Growing incomes, motorization, and sprawling low-density development patterns work to reinforce each other: as more people purchase vehicles, they are able to settle further out from the city center, inducing more development and lower housing costs but entailing longer travel distances, reinforcing the dependence on the automobile and in turn making public transit less economically viable.

2.10 Per capita car ownership in 10 LAC countries rose from 0.09 in 1990 to 0.20 in 2008 (Acevedo et al., 2009). A large share of that growth occurred in the middle- to higher-income countries, such as Brazil and Mexico. In Brazil, for example, where incomes are rising and the federal government subsidizes new cars, auto ownership is growing faster than GDP (see Box 2.1). Motorization rates in Peru have increased by 35%, from 52.34 vehicles/1000 people in 2006 to 71/1000 people in 2012 (Ministerio del Ambiente, 2014).[19] Moreover, growth in motorcycle ownership rates has surpassed that of autos in many cities; motorcycles make up 10-49% of the vehicle fleet in LAC cities, leading to a number of safety and environmental concerns. Given current trends in income and economic growth, motorization rates are expected to more than double by the year 2030 (relative to 2002).

Box 2.1. Encouraging the purchase of private vehicles in Brazil

The number of automobiles in Brazil doubled between 1999 and 2008 (World Bank, 2011), surpassing the growth rate of both GDP and the population, and turning Brazil into the fifth-largest automobile market worldwide. Federal government policies encourage this growth—for example, the 2012 economic stimulus plan reduced taxes on industrial products and thus also reduced the price of vehicles by 10% (IEA, 2013). Other federal policies provide financial assistance for the purchase of private vehicles, offering financial installment plans of up to 80 months. Although these polices give lower-income families the opportunity to acquire vehicles, they risk increasing emissions in the transport sector and counteract efforts to widen the availability of public or non-motorized transport.

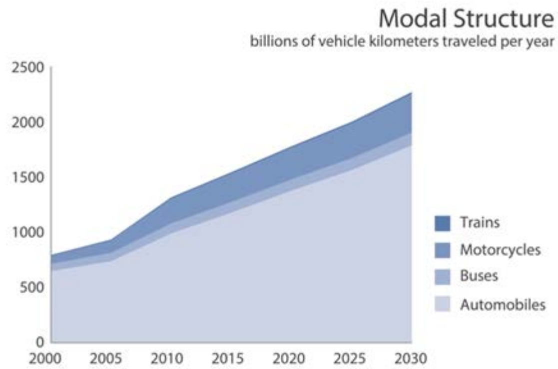
2.11 While public transport and non-motorized modes (i.e., walking and biking) still account for a high share of passenger transport in LAC cities (roughly 70% of trips), there has been a decline in the share of collective modes in favor of more carbon-intensive private vehicle usage (autos and motorcycles) (Schipper et al., 2009, Timilsina and Shrestha, 2008). Not surprisingly, between 2000 and 2030 vehicle miles traveled for passenger transport are expected to rise fastest among motorcycles and cars—by 401% and 176%, respectively—and much less for trains and buses: 75% and 71%, respectively (ICCT, 2012) (Figure 2.3).[20] Widespread fuel subsidies for transport and tax breaks on vehicle imports in LAC contribute to these trends (IMF, 2013; Rios et al., 2013; Campodónico, 2009).[21] Among freight modes, the shares of air and road, which are more carbon-intensive than rail and water, have increased, driven by growing trade, changing commodity mixes, increase in demand for "just in time" deliveries, and deregulation of the freight sector (which favors road transport) (IPPC, 2014).

[19] The motorization rate growth is about 5.1% per year since 2000 (ITDP, 2011).

[20] Emissions per vehicle-kilometer are a function of the age of the fleet, congestion levels, and technical specifications that affect energy efficiency, as well as the fuel mix, the energy intensity of the vehicle fleet, and the average load factors (passengers or tons carried per vehicle) (Schipper et al., 1999).

[21] Mexico, Argentina, and Ecuador have high levels of gasoline subsides, accounting for 1.5%, 2.3%, and 5.3% of their GDP, respectively (in 2008) (Rios et al, 2013). Fuel subsidies and a lack of vehicle emissions standards and enforcement also contribute to increased air pollution and GHG emissions. These subsidies have been found to be highly regressive; even though they are intended to help the poor, the IMF found that more than 80% of the economic benefits go to the richest 40% of households (IMF, 2013).

Figure 2.3. Vehicle-kilometers, by vehicle type



Source: ICCT, 2012.

2.12 The sector's high reliance on fossil fuels has also resulted in its high carbon intensity and in growing CO_2 emissions associated with growing energy consumption. Most LAC countries rely primarily on diesel and gasoline (48% and 46% of end-use energy, respectively) as transport fuels, except Brazil, which has actively promoted biofuels, and Argentina, which uses liquefied petroleum gas for roughly 20% of its energy for transport (Timilsina and Shrestha, 2008). The increasing importance of diesel fuel, which grew from 37% to 46% of end-use energy consumption between 1980 and 2005, has increased emissions of particulate matter and black carbon in countries with poor-quality diesel and aging vehicle fleets.

2.13 Average vehicle fleet age varies widely by country—for example, 9 years in Mexico (see Box 2.2) and 20 in Peru (UNEP, 2011). In many LAC cities, an aging vehicle fleet has meant not only high levels of pollution, but also lower average energy efficiency of the vehicle fleet, and thus higher GHG emissions.

Box 2.2. Energy intensity of freight transport in Mexico

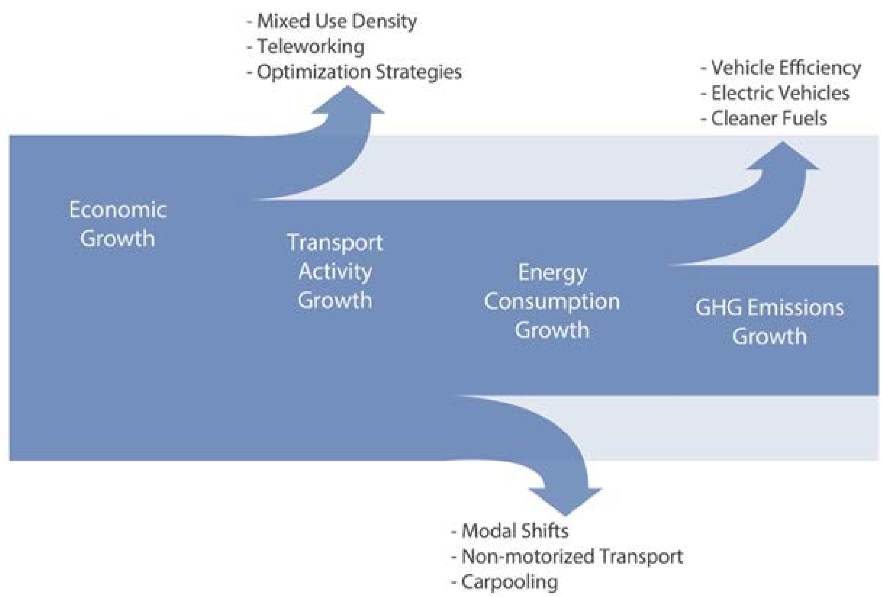
For freight transport, one of the factors that affect energy intensity is the average age of the fleet. At the end of 2013, of Mexico's fleet of 715,000 freight transport vehicles, 46% were more than 15 years old, and the average age was 17 years (SCT 2014); this means less efficient engines and higher emissions of pollutants and GHGs. Another factor affecting energy efficiency is the importation of used vehicles from the USA—more than 5 million between November 2005 and December 2012 (CMM 2013). These vehicles often have mechanical faults or fail to comply with performance standards, and they emit more atmospheric pollutants than newer cars. The study carried out by the Centro Mario Molina revealed that used cars in Ciudad Juárez produce 101% more nitrous oxides (NOx), 99% more hydrocarbons, and 61% more CO2 than do automobiles in Mexico City. Furthermore, 67% of these vehicles were trucks, minivans, or SUVs, with a fuel consumption of 6 km/liter, three times greater than that of a new car.

2. Strategies to reduce emissions generated by transport

2.14 Transportation infrastructure investments have long-term implications for the spatial organization and development of cities and regions, and for the subsequent environmental and social sustainability of transport systems. Roads, mass transit, and bikeway investments both respond to and mold the structure of the transport sector, land use patterns, and travel behavior in urban and nonurban areas. The blueprint of land use and transport infrastructure in turn affects the efficiency of transportation systems, the subsequent levels of GHG emissions, and the long-term viability of future investments in lower-carbon transport systems. Emerging economies and cities thus have a unique window of opportunity to avoid the lock-in effects their more developed counterparts face by investing in sustainable transportation futures.[22]

2.15 While increasing GDP is associated with growing motorization, vehicle-kilometers traveled, and thus increased emissions, many groups and scholars call for delinking economic growth from carbon emissions through a sustainability approach. Decoupling emissions from economic development calls for the development of sustainable transport systems (see Figure 2.4)—that is, transport that provides accessibility and mobility for all groups while supporting human and ecosystem health (IPCC, 2014). Such transport systems attempt to strike a balance among economic growth, social development, and the environment, with mobility, human, and ecosystem health as a long-term goal, viewed from the perspective of the person rather than the vehicle.

Figure 2.4. Decarbonizing the economy



Source: OVE.

2.16 Given the positive economic growth projections in LAC, decoupling growth in GDP from growth in emissions is particularly relevant for the Region, as the effect of growth in travel often outweighs mitigation measures (IPCC, 2014). Burgeoning economies and

22 For example, cities that choose to invest in new, expanded, or widened roads, without coordinated land use plans, may develop in a lower-density and sprawling pattern that is difficult to serve cost-effectively with public transport and thus will tend to lock in an automobile-dependent society. So, while investments in environmentally and socially sustainable transportation systems may in the short run yield local benefits such as reductions in air pollution, accidents and congestion, and transport costs, long-run benefits, all else being equal, will tend to include reductions in GHG emissions (relative to the counterfactual) or a lower-carbon development path.

fast-growing urban areas often experience lock-in effects because of the slow turnover of vehicle stocks and the relative inertia of fixed infrastructure. By investing in low-carbon infrastructure, such as mass transit, bicycle, and pedestrian infrastructure for passenger transport and multimodal green logistics platforms for freight, cities can avoid these lock-in effects and achieve a more sustainable transport path.

2.17 Nevertheless, simultaneously achieving economic, social development, and CC objectives in a single project presents challenges and trade-offs that require setting priorities and balancing competing interests. For example, technology that could deliver the best results in terms of reducing emissions can be very expensive and affect the funding of the project, or cause the fees to be unaffordable for the poor. Or incentives for everyone to have access to a private car can have a social purpose but contrast with economic and emission reduction objectives. However, given that the drivers of growing GHG emissions are highly interrelated with factors that contribute to other negative externalities, addressing such local issues as air pollution, congestion, and energy efficiency often results in significant benefits in terms of reductions in GHG emissions. Many measures to reduce GHG emissions also result in several other co-benefits to transportation systems and can in fact be selling points for such measures, since localities facing competing problems are not likely to view mitigating GHGs as a primary short-run concern.[23]

2.18 In the context of sustainable transport, strategies to mitigate emissions from transport activities can be described following the policy framework known as the "Avoid, Shift, Improve" paradigm (Schipper, 1999):

a. **Avoiding unnecessary trips or reducing trip distances** through multimodal transportation and land use planning that reduces the distances between origins and destinations (including through transit-oriented development, urban growth boundaries, increased density, and mixed uses around main transport corridors) and through travel demand management strategies (carpool lanes, congestion pricing, parking pricing and regulation, and so on).[24]

b. **Shifting to lower-carbon modes** (such as biking, walking, and modernized public transport for public transport, and rail or water modes for freight transport).

c. **Improving the energy efficiency of passenger and freight vehicles** and/or transportation systems (e.g., logistics, traffic light modernization, and so on), and **reducing the carbon intensity of fuels** for transport (to lower-carbon fuels).

23 For example, since transport is still primarily fueled by fossil fuels, efforts to improve the energy efficiency of vehicles and systems will reduce both CO_2 and pollutant emissions. In addition, reducing congestion through pricing and transport system improvements, improving vehicle flows through logistics planning, and improving road maintenance will improve the energy efficiency of the movement of goods and people, lower transport costs, and improve productivity. Reducing the sector's reliance on fossil fuels can also bring economic benefits in terms of reducing vulnerability to price shocks associated with the volatility of the fossil fuel market and dependence on fossil fuel imports.

24 Transport pricing works by providing incentives to travelers to avoid trips by high-emission modes during times or in locations that contribute to higher emissions—for example, peak-hour, single-occupancy trips in highly congested corridors.

2.19 The potential effects of such measures vary. For example:

a. Pricing mechanisms can be used to influence consumer uptake of more fuel-efficient and lower-carbon vehicles, and to shape travel behavior to decrease emissions.[25] For example, in central London, congestion pricing paired with improvements in public transportation led to a 15% decrease in traffic (ICCT, 2013).

b. Investments in mass transit systems have brought about small but important shifts (~4-5% of trips) to public transport.[26] Investments in walking and biking networks can induce increased walking and bike trips by up to 20% (IPCC, 2014). A modern public bus emits, on average, half the CO_2 of a small petroleum-fueled car per passenger-km (Kopp et al, 2013). While metros and light rails[27] have lower direct CO_2 emissions than cars, their capital costs are substantially higher and start-up times longer than those of BRTs. High-speed rail can substitute for short-distance air travel and save 65-80% in emissions (IPCC, 2014).[28] For freight transport, predicted growth in freight trucking could be cut in half, and fuel consumption reduced by 20%, by switching to rail. However, while rail[29] and water modes can be more competitive for interurban long distance trips, road freight will likely continue to dominate in urban areas because of the existing dense road networks (IPCC, 2014).

c. For light-duty vehicles (LDVs), fuel efficiency gains of up to 50% (in terms of fuel use per kilometer) are possible through improvements to drive-train technology (25%) and to energy loads (vehicle weight, aerodynamics, and so on). For medium- and heavy-duty vehicles, in non-OECD countries where truck fleets are old, substantial gains in energy efficiency are possible through fleet renewal. While shipping and rail modes are already relatively very efficient, rail can improve through multiple drive trains and load-reduction measures, aerodynamic measures, and energy-efficient electronics (IPCC, 2014). Since up to 60% of truck trips are made with empty trucks, improving the efficiency of goods movement through logistics planning can generate substantial savings (Kopp et al., 2013).[30]

d. Advanced propulsion systems, such as those used by electric vehicles (powered by fuel cells or plug-in batteries), and hybrid technologies also offer large potential

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25 For example, since fuel-efficient vehicles tend to cost more, tax breaks and incentives can be used to tip the economic scale toward cleaner vehicles.

26 For metro and light rails, maintaining high ridership or system occupancy rates is critical to achieving reductions. This in turn requires a systems approach that integrates modes and land use around stations to support ridership. BRTs have the potential to substantially reduce emissions by simultaneously increasing the efficiency of the system, improving bus technologies, and encouraging shifts away from cars toward public transit.

27 The emissions of light rails are equal to or lower than those of buses, depending upon the type of energy used and load factors; however, light rails cost substantially more (Kopp et al., 2013).

28 However, since high-speed rail has large capital costs, it requires dense concentrations of populations around stations and high demand to justify the costs, and may be relevant in only a few LAC countries, such as Brazil (Kopp et al., 2013). Similarly, light rail and metro systems need high levels of demand to justify the high capital investment costs.

29 Freight rail, however, may need subsidies to compete with road to be completely competitive, since roads are already heavily publicly subsidized and are usually used free of charge (Kopp et al., 2013).

30 In 2009 the rate of empty hauls for fright trucking was 35% in Mexico and 30% in Colombia (Kopp, 2013).

savings over standard internal combustion engines. Electric vehicles have zero tailpipe emissions; however, their systemwide emissions are dependent on the carbon intensity of the electricity grid.[31] Electric vehicles (particularly those that are powered by fuel cells) and hybrids are still considerably costlier than standard vehicles, however, so increasing their use would require substantial financial incentives as well as infrastructure investments for charging stations.[32]

e. Lower-carbon fuels include compressed natural gas (CNG), biofuels,[33] electricity generated by a low-carbon power grid, and hydrogen. CNG used in place of diesel or gasoline can save up to 25% of tailpipe emissions and 10-15% of lifecycle emissions (IPCC, 2014). CNG also emits substantially less in local pollutants (particularly particulate matter (PM_x) and black carbon[34]). However, potential leakage of methane,[35] a highly potent GHG, should be monitored closely. Biofuels reduce direct tailpipe emissions of CO_2 by 30-90% percent per kilometer traveled compared to diesel and gasoline; however, in some cases, indirect emissions from land use change and heavy fossil fuel usage in production can swamp savings and result in net increases.

2.20 The cost-effectiveness of mitigation measures ranges widely, depending upon the context of their implementation (IPCC, 2014). Energy efficiency improvements to LDVs and long-haul[36] heavy-duty vehicles (HDVs) have the most short-term cost-effective mitigation potential, with very low or negative costs (i.e., net economic benefits) (IPCC, 2014). Efficiency improvements to short-haul urban HDVs can cost over US$100 per ton of CO_2 saved. For electric vehicles, the costs correspond to the carbon intensity of the electricity matrices, with low-carbon matrices implying a cost of US$200 (constant 2010 $) per ton of CO_2. Mitigation cost-effectiveness for biofuels is highly sensitive to the cost of the biofuels relative to gasoline and diesel and the net direct and indirect emissions associated with production; it ranges from US$0 to US$80/tCO_2 (constant 2010 $) (IPCC, 2014).

2.21 Critical to the success of these measures is a multipronged and integrated approach that includes demand- and supply-side measures (see Table 2.1).

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31 Battery electric vehicles have very high drive-train efficiency (80% compared to 20-30% for an internal combustion engine). Fuel cell vehicles are 35-45% more fuel efficient than a typical internal combustion engine (IPCC, 2014).

32 A lack of interest in purchasing fuel-efficient vehicles stems from information asymmetries, consumer information overload, and uncertainty about future fuel prices and thus about payback rates on higher up-front investment costs (IPCC, 2014). In addition to pricing incentives, fuel economy mandates in combination with restrictions on old vehicle imports may be needed to improve energy efficiency.

33 Such as biofuels that have sustainable land use practices—that is, they do not result in increased indirect emissions of GHG from land use—and electric vehicles that operate on electricity from biofuels based on a high share of renewable resources.

34 Diesel oxidation catalysts and particulate traps can substantially reduce black carbon and PM_x (IPCC, 2014).

35 CNG is natural gas made up mainly of methane (CH_4), stored at high pressure. Methane has more than 100 times the energy (heat)-trapping potential of CO_2 (Source: http://www.edf.org/methaneleakage). Leakages can occur throughout the natural gas supply and distribution chain, including from pipelines, at fueling stations, and from vehicles such as transit buses and medium- and heavy-duty trucks (Source: http://wvutoday.wvu.edu/n/2013/03/04/scemr-release.)

36 Long-distance heavy trucking.

Table 2.1. Demand- and supply-side strategies for low-carbon mobility

	Avoid	Shift	Improve
Objective	Reduce car dependency, reduce journey distances, and enhance the attractiveness of less contaminating modes of transport.	Offer alternatives to traditional means of transport and use incentives and regulations to encourage change to more efficient modes.	Improve the energy efficiency of existing systems using new technologies, operational structure and connectivity, or management practices.
Demand-side interventions	Fuel prices, road taxes, integrated strategies for managing travel demand, parking regulations, protection of vulnerable zones, restrictions on urban sprawl, land use planning.	Zero-emission zones, restrictions on motorized transport, parking regulations, public transport process, vehicle congestion charge.	Management practices, vehicle standards, fuel regulations, speed limits.
Supply-side interventions	Public-transport-oriented urban development, development of logistics platforms.	Public transport infrastructure, bicycle and pedestrian infrastructure, investment in railway systems, and development of waterway systems. Polices to foster private sector participation, multimodal integration.	Optimize public transport routes, intelligent transport systems, efficient vehicle technologies, second-generation biofuels, infrastructure for electric vehicles, aerodynamic design for freight vehicles, infrastructure maintenance.

Source: Adapted from Dalkmann and Huizenga, 2010.

2.22 For example, in many cases reductions in emissions from improvements in fuel economy have been swamped by increases over time in the overall number and length of trips (ton-kilometers and passenger-kilometers traveled) (Schipper et al., 2009; Kopp et al., 2013), as fuel-efficient vehicles lower the cost of travel by motor vehicles and increasing incomes and economic growth in turn spur increased transportation of goods and people. Similarly, widening roads or building new roads has been shown to only temporarily alleviate congestion in most cases, as lower travel times induce new trips (lower cost increases demand for travel) in the short run, and new land developments on cities' outer edges (spurred by new roads) induce an increased number and length of motorized trips in the long run. Finally, transportation pricing (such as cordon and congestion pricing, fossil fuel taxes, parking pricing to discourage single-occupancy vehicle trips in highly congested areas) is less effective unless there are viable and high-quality sustainable transportation options.[37] Conversely, investments in public transit would be expected to have higher payoffs in terms of ridership when coupled with regulations and pricing schemes to discourage private vehicle use (i.e., parking pricing and restrictions to discourage car trips to downtown areas) and fare subsidies for public

[37] In central London, for example, congestion pricing paired with improvements in public transportation led to a 15% decrease in traffic. Implementing parking pricing schemes led to further declines (ICCT, 2013).

transport (as in London). Thus a holistic and integrated approach that takes into account both supply-side and demand-side economic factors is necessary to reduce GHG emissions.

2.23 A variety of policies and strategies have been adopted throughout LAC to reduce GHG emissions (see Box 2.3).

Box 2.3. Examples of policies adopted in LAC

National policies and plans. Colombia, Peru, Brazil, and Mexico have all implemented national climate change plans that include the transport sector. Peru signed and ratified all international treaties and agreements related to the sustainable use of natural resources and the mitigation of negative impacts on the environment. Colombia has recently received funding for a Nationally Appropriate Mitigation Action plan, while Chile, Mexico, and Peru are developing theirs (source: http://www.transport-namadatabase.org/)

Vehicle imports, emissions standards, and scrapping programs. Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, and Venezuela have all banned importation of used vehicles in the past 5-10 years; Costa Rica and Panama require imported vehicles to meet emissions test standards; and Cuba, Dominican Republic, El Salvador, Honduras, Jamaica, Mexico, Paraguay, and Suriname have imposed vehicle age restrictions on imports (UNEP, 2012). Mexico and Argentina require new vehicles to meet, respectively, Euro 4 and Euro 5 emissions standards—which primarily control local pollutants but also have lower CO_2 emissions (particularly Euro 4 standards compared to Euro 1-3) (UNEP, 2012; Cooper et al., 2012). Several cities, in conjunction with investments and reform to the public transport sector, have scrapped thousands of old buses.

Fuel efficiency standards. Fuel efficiency standards, which could have a large impact on CO_2 emissions, are not widely used in LAC: Mexico has set its first fuel efficiency standards for LDVs and HDVs, and Brazil has incentives for fuel efficiency for LDVs but no standards (Global Fuel Economy Initiative, 2014). In fact, because of an aging vehicle fleet and growing taste for larger vehicles, fuel efficiency has worsened in some cases.

Fuels and alternative low-carbon vehicle technologies. Biofuels are used widely in Brazil—ethanol in automobiles and biodiesel in trucks. Ethanol produced in Brazil is estimated to emit 44-60% less in GHG emissions. However, *net* GHG emissions associated with biofuels (both indirect and direct emissions) in other contexts/countries has been the subject of great controversy and uncertainty because of the indirect emissions associated with their production and associated land use practices (ICCT, 2013). CNG, which has substantially lower emissions of several local pollutants (particularly PM_x and black carbon), was used for the first BRT line in Lima, Peru, and now is being planned for use in several bus lines in the city (Protransporte, 2014, personal communication with president of bus agency). Argentina uses CNG for approximately 19% of its transport (Timilsina and Shrestha, 2008). However, since methane is a potent GHG, leakage from buses and fueling stations could result in higher net GHG emissions (Schipper, et al., 2009). More than 50 cities in LAC have begun to renew their bus fleets; while electric vehicles and hybrid technologies are not widely used in LAC, Colombia, Mexico, and Brazil have been involved in testing programs for such technologies.

Modal shifts. LAC cities have invested in numerous BRT systems—bus systems that are designed to operate at capacities near or equal to those of a rail-based systems at a fraction of the cost and construction time. When well implemented, these systems can substantially reduce emissions by simultaneously increasing the efficiency of the system, improving bus technologies, and encouraging modal shifts away from cars toward public transit (or at least stemming the trend of increased travel via private automobiles).

Land use. Curitiba is well known for having successfully planned its land use around BRT corridors, using a mix of land use and a gradient of densities (higher near transit stations and declining toward residential areas) to support transit usage (Suzuki et al., 2013), resulting in one of the world's highest urban transit usage rates (70%), an increase of 62% since the system's inception (Kopp, 2013). Bogotá and Rio are currently examining ways to improve land use planning around transit corridors. However, most cities in LAC have not implemented such planning extensively.

Vehicle use restrictions. Many cities in LAC have implemented restrictions on vehicle usage (known as *pico y placa*). However, these restrictions have been shown to have a perverse impact: some households buy a second car and increase their car usage during weekends and typical off-peak hours (Gallego et al., 2013).

Pricing and incentives that affect emissions from transport. Congestion pricing schemes have not yet been implemented in LAC because of political constraints and high initial capital investment costs; however, proposals for congestion pricing are being considered in Bogotá, Santiago, and São Paulo (Rios et al, 2013).

B. Transport and adaptation to climate change

2.24 The LAC Region is exposed and highly vulnerable to the effects of climate change, which have already had a high impact in the Region (Hesselbjerg, 2014). Increased rainfall, longer droughts, rising sea levels, tidal surges, and a higher intensity of extreme weather events puts the viability and stability of the transport systems at risk, and as a consequence can also have significant economic effects on the countries' economies.[38] The impacts on transport infrastructure and services affect the Region's economic development and competitiveness,[39] put pressure on the fiscal stability of governments,[40] lead to adverse health impacts because of reduced access (e.g. medical centers) and potential increased exposure to extreme temperatures and other climatic conditions to users of transport systems (including public transit and road users[41]), and hamper the countries' capacity to respond to the emergencies caused by adverse climatic phenomena.[42]

2.25 Countries in LAC, like most developing countries, often have insufficient transport infrastructure to resist climatic shocks (Cambridge Systematics, 2009).[43] Floods, tidal waves, and rising sea levels will have significant impact on transport infrastructure, principally on the coasts of Brazil, Mexico, and Venezuela and among the Caribbean islands (ECLAC, 2012b). If the technical specifications of port infrastructure remain unchanged, ports' capacity to withstand waves, storms, and rising sea levels could be reduced by 60% (ECLAC, 2012a). The economic costs of reconstructing and rehabilitating transport infrastructure are particularly high. In countries such as Mexico, although the civil protection system and disaster relief have reduced the number of fatalities, the increase in the number and intensity of hydro-meteorological events is translating into higher economic costs and damage to infrastructure (CENAPRED, 2012).[44]

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38 A study by Mexico's Environment and Natural Resources Secretariat (Secretaría de Medio Ambiente y Recursos Naturales) estimated that the impact of climate change by the year 2100 would be 6.22% of the country's GDP (SEMARNAT, 2009).

39 The El Niño and La Niña phenomena in 2010-2011 affected 17% of the road network and 92 bridges in Colombia. They caused damage worth 2% of GDP, and 38% of this damage happened to the transport infrastructure (Ministerio de Transporte 2012).

40 A study of Mexico's Natural Disaster Fund (Fondo de Desastres Naturales de México) found that between 2000 and 2011, 57% of the fund's resources went toward road reconstruction (World Bank, 2012).

41 For example, temperatures within public transit systems and along highways can be higher than surrounding temperatures due to heat island effects and/or poorly ventilated tunnels within metros or in roadways.

42 Transport infrastructure, apart from its key role in economic and social development, also plays a vital part in responding to emergencies caused by extreme weather events that can affect the delivery of food, medicine, or building materials. Flooded roads and fallen bridges impede access to the affected areas. After an emergency, infrastructure damage also affects people's access to their workplaces and hinders the continuation of productive and social activities (OECD, 2013).

43 An analysis of the last 40 years of extreme weather events identified Mexico and the countries of Central America as the most exposed to floods in the Region (Garlati, 2013). The Caribbean countries are more exposed to hurricanes, tropical storms, and tidal waves. Brazil, Mexico, Argentina, and Venezuela have more inhabitants and transport infrastructure concentrated in the coastal areas and exposed to flooding, storm surges, and rising sea levels (ECLAC, 2012a).

44 In 2011, floods in Tabasco, Mexico, had a total impact of MXN 10,304 million, of which 43.8% was caused by damages to the road infrastructure (CENAPRED, 2012).

1. Climate change impacts on transport systems

2.26 Climatic phenomena, whether extreme or not, affect transport systems in two ways: they can affect the availability of energy sources, or they can exert direct effects on the infrastructure. Damage to infrastructure, in turn, can have a destabilizing effect on transport networks, or can prevent the transport systems from fulfilling their function when it comes to an emergency situation. Table 2.2 lists examples of the effects of CC on transport systems.

Table 2.2. Impacts of climate change on transport systems

Dimensions	Possible impacts
Energy sources	· Droughts can harm electrical energy supply. · Extreme events can cause distribution failures and thus fuel shortages.
Infrastructure	· Rain can undermine roads, affect drainage systems and the stability of embankments, and affect river navigability. · Rains, floods, and drought can affect the stability of foundations. · Droughts can affect river navigability. · Storms can affect airport services. · Floods may damage bridges and streets in urban areas, and can cause massive damage to transport systems. · Storm surges can damage coastal infrastructure. · Rising sea levels can affect port facilities.
Transport network	· Storms and floods can cause damage to important primary segments in the transport network or secondary and connecting sections, consequently reducing the network's capacity to carry passengers and freight.
Attendant emergency situations	· Transport network interruptions caused by storms can limit access to affected areas and hamper rescue efforts. · Reduced port and airport services hinder the arrival of humanitarian aid. · The transport infrastructure needed for evacuation may be out of service or inaccessible after flooding.

Source: Cambridge Systematics, 2009.

2. Adaptation to Climate Change Strategies for the Transport Sector

2.27 Adaptation to CC in the transport sector seeks to reduce the vulnerability[45] of the infrastructure and the transport system, reducing their exposure to natural hazards, and to mitigate the risks of extreme weather events. The strategies used to achieve these goals can be classified into three main categories: (i) those oriented to identifying risks[46] and vulnerabilities,[47] (ii) those that seek to protect or strengthen the vulnerable infrastructure, and (iii) those that seek to create alternative routes to enhance the

45 According to the IPCC, vulnerability to climate change can be defined as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC AR4 Synthesis Report Glossary).

46 According to the UNISDR, a risk can be defined as "the combination of the probability of an event and its negative consequences" (UNISDR 2009 Terminology on Disaster Risk Reduction).

47 This also entails assessing the value of the infrastructure relative to the risks to prioritize adaptation measures.

transport system's resilience (California, 2009; Cambridge Systematics, 2013).[48] In addition, when new infrastructure is built, risk assessment mapping should inform the location of infrastructure.[49] Table 2.3 lists examples of adaptation strategies in each of these categories.

Table 2.3. Transport sector adaptation strategies

	Risk assessment	**Infrastructure protection/strengthening**	**Alternate route creation**
Objective	Identify the segments of the system that are vulnerable to the effects of climate change and that represent a high risk.	Implement works aimed at protecting the infrastructure, or improve technical specifications to enhance its resistance to climatic phenomena.	Create networks and transport systems that can continue to function even if there are disruptions in some segments of the system (road redundancy).
Interventions	Risk and vulnerability atlases. More desegregated climate models, which include climate change projections. Inventory of existing infrastructure and its condition.	Build flood barriers or raised platforms. Extend drainage systems. Change quality of materials or the minimum design standards.	Multimodal integration. Construction of alternative roads in critical sections. Complementary transport systems.

Source: adapted from Cambridge Systematics (2013).

2.28 Given that transport systems are more than the sum of the individual infrastructures, adaptation strategies should go beyond merely strengthening the existing infrastructure. Maintaining the system's capacity to move people and goods might be a better strategy than trying to strengthen individual segments (US DOT, 2012). On the one hand, the idea is to reduce *physical vulnerability* through technical specifications or complementary works that enhance the resilience of a particular infrastructure; but on the other hand, it is important to also address *functional vulnerability*, which implies identifying the most critical segments and making sure that in the event of disruptions there are alternatives available to maintain service provision, access to vulnerable areas, and the continuation of economic and social activities.

2.29 The transportation infrastructure in LAC has been undergoing constant improvements in its technical specifications and initiatives to modernize the transport networks. Although these improvements tend to be based on historic hydro-meteorological information, they can nevertheless help to enhance the capacity to resist the effects of CC and can often be

48 A last resort measure is to relocate the infrastructure, when it is no longer possible to sustain the service, when the cost of strengthening it is higher than building a completely new alternative, or when people and activities are being displaced toward other areas (Cambridge Systematics, 2012).

49 This is particularly relevant in developing countries in LAC that have infrastructure gaps (Kopp et al., 2013).

cost-effective[50] when compared to the cost of responding to emergencies and rebuilding infrastructure affected by climate change (Fay and Morrison, 2007; Sanchez and Wilmsmeier, 2005). LAC countries—notably Brazil, Mexico, Peru, and Colombia—are beginning efforts to adapt their infrastructure and transport systems to CC.[51]

2.30 Some LAC countries' strategies have focused on identifying the risks presented by the effects of CC. For example, in Mexico the federal agencies are developing an atlas of risks, a diagnostic instrument that helps identify investment priorities (Comisión Intersecretarial de Cambio Climático, 2012). Once risks have been identified, measures can be taken to change the technical specifications of the priority road sections, or to survey the resilience of the transport network in case of emergencies. In Brazil, the federal government and states such as São Paulo have transport and CC plans that aim to identify transport infrastructure vulnerabilities to CC and propose measures to reduce its impacts (São Paulo, 2011).

2.31 Mexico, Peru, and Colombia have developed methodologies to quantify the economic value of the vulnerability of segments of the road and rail network and identify the sections that represent the highest economic costs for the country in the event of natural disasters and emergencies (Hernández and Angélica, 2011). With this information, the vital segments needed to respond in a disaster can be identified and priority can be given to those sections to reduce the economic impact of disruptions to the transport network as a consequence of extreme climate events.

C. Climate finance

2.32 Climate finance mechanisms have been developed to help cover the incremental costs involved in implementing low-carbon and more resilient transport projects in developing countries. Financing sources for adaptation to climate change for transport are small compared to those for mitigation, but they have been increasing globally since 2011. The four main sources of climate finance for mitigation for transport are the NAMA Facility, the Clean Development Mechanism (CDM), Clean Technology Fund (CTF), and Global Environmental Facility (GEF).

- The CTF (US$4.2 billion globally from 2008 to January 2009) and GEF (US$8.8 billion globally over 1991-2009) are sources of climate financing from multilateral institutions such as the World Bank, Asian Development Bank, and IDB for transport projects that include GHG emission reductions as an element.

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50 The costs and benefits of adaptation measures should be weighed relative to the expected CC risks to prioritize and choose adaptation measures, using a cost-benefit framework. (California, 2009; Cambridge Systematics, 2013; US Federal Highway Administration, Transportation Research Board (TRB) Presentation, January 2014).

51 Mexico's national strategy on CC establishes as one of its priorities to "reduce vulnerability and increase the resilience of strategic infrastructure" (ENCC, 2013). The plan of action for climate change adaptation and mitigation adopted by Peru in 2010 shows the need to evaluate the vulnerability of the transport sector and create a national atlas of risks for transport infrastructure that enables investments to be prioritized (http://cdam.minam.gob.pe/novedades/plancambioclimatico.pdf).

- The CDM is one of the most widespread carbon finance mechanisms. However, because of the mechanism's rigorous evaluation requirements and the difficulty of using such methods for the transport sector, only 30 of the 5,000 registered CDM projects have been for transport. In addition, since the CDM is tied to directly to carbon markets, the fall in the price of carbon has undermined the effectiveness of the mechanism.

- NAMAs have recently emerged as a new and more appropriate financing and planning tool to fund CC-friendly transportation projects. They include plans, policies, actions, and projects that can be expected to reduce emissions from transport (Lefevre and Leipziger, 2014). There is a new fund through the UNFCC to finance NAMAs. Colombia, Peru, Brazil, and Mexico have all implemented national climate change plans that include the transport sector.

III. ASSESSMENT OF IDB'S WORK IN TRANSPORT AND CLIMATE CHANGE

A. Transport and Climate Change Portfolio

3.1 This chapter assesses the extent to which IDB's transport lending portfolio has directly and indirectly addressed CC mitigation and adaptation concerns. During 2004-2013, IDB approved 125 transport[52] loans for a total amount of US$14.96 billion.[53] Of this portfolio, 65% financed road projects, mainly rehabilitation and/or extension of existing infrastructure, and loans for urban transport (metro systems, BRTs, or integrated bus systems) accounted for 21% of the sector portfolio. The private sector window represented 17% of the total transport lending and financed mostly toll roads.[54] Lending has been highly concentrated in the Southern Cone (see Figure 3.1).

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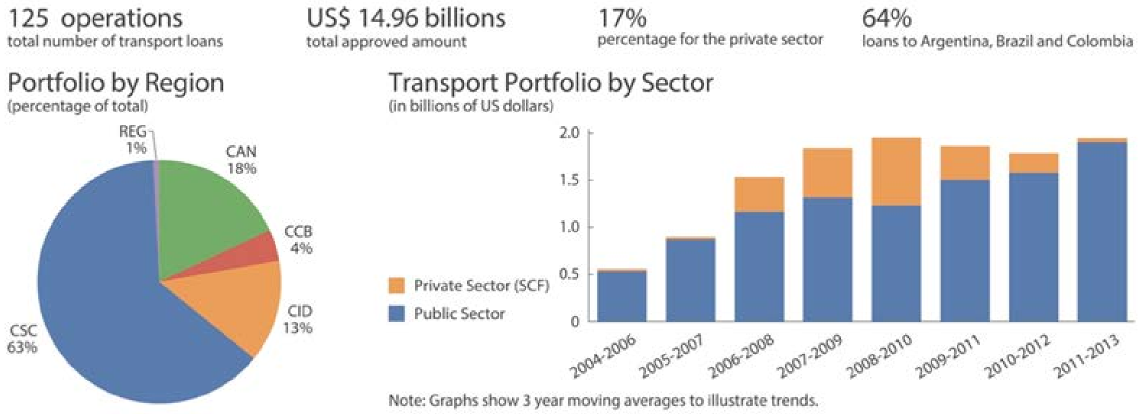
[52] Includes loans prepared by INE/TSP and SCF.

[53] This portfolio includes investment and policy-based loans only; investment grants, guarantees, and credit lines are not included.

[54] Several projects related to metros and BRTSs include public-private alliances, but the Bank primarily finances infrastructure provision through sovereign-guaranteed loans.

Figure 3.1. Transport sector loan portfolio, 2004-2013



Source: OVE.

3.2 Even though all transport projects potentially affect the level of GHG emissions from the sector, for purposes of this evaluation OVE classified projects into three main categories[55] on the basis of their link to climate change, as follows:

a. **Explicit climate change projects:** projects whose objectives explicitly include reducing GHG emissions or enhancing the resilience of transport infrastructures and services.

b. **Implicit climate change projects:** projects whose objectives do not explicitly include addressing CC mitigation, but for which the literature and the empirical evidence indicate that the type of intervention can reduce GHG emissions.[56] The loan proposal may recognize CC mitigation as a co-benefit.

c. **Projects with no climate change objective:** projects whose designs did not take the climate change dimension into account and did not meet the category (implicit) above, but that nevertheless could have a potential positive or negative impact in terms of emissions.

3.3 Using these definitions, a CC-related project is one that is either explicitly or implicitly related to climate change. Of the 125 transport loans approved between 2004 and 2014, 33% of operations are directly CC-related because they have either explicit (12 loans) or implicit objectives (29 loans). The total amount of

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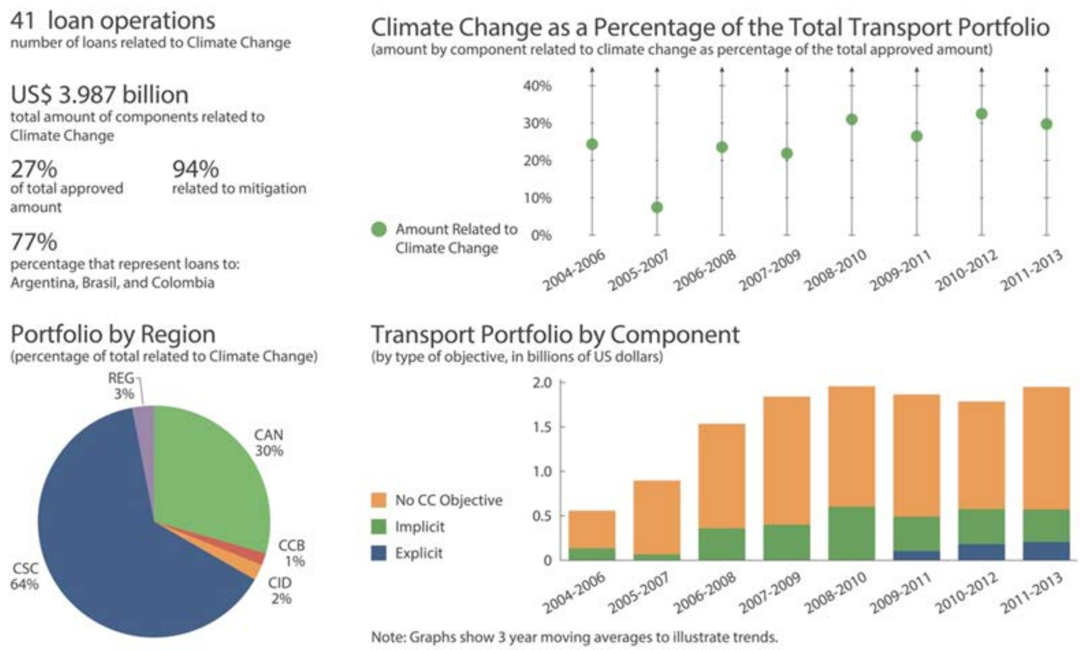
55 OVE reviewed the components of each project to determine what amount of the approved loan is related to adaptation to climate change or emissions mitigation.

56 CC mitigation projects included those that support urban and interurban logistics, metro and commuter rail, integrated bus systems, BRTs, non-motorized modes, and urban mobility planning and studies (which could include plans, project preparation, or studies for multimodal sustainable urban transport systems and/or projects, or plans and/or studies for complementary measures for such systems), waterways (not including ports), and rail. Only mitigation-related projects were included in the implicit category; all projects seeking to build/rehabilitate infrastructure to increase resilience to climate events were included in the explicit category.

CC-related lending was US$3.99 billion, or 27% of lending resources approved for the sector (see Figure 3.2). Investment lending accounted for the lion's share of the resources (83%), with programmatic and TC loans far behind (7%). Loans to the private sector made up only 10% of the CC-related portfolio.

3.4 CC-related loans have been approved in 14 of the Bank's 26 borrowing member countries, but 77% of the amounts approved have been concentrated in Argentina, Brazil, and Colombia. In contrast, although Belize and the Caribbean Region are highly exposed to natural disasters, they have only four loans, representing just 2% of the total amount approved in the period.

Figure 3.2. Climate-change-related loans in the transport sector, 2004-2013



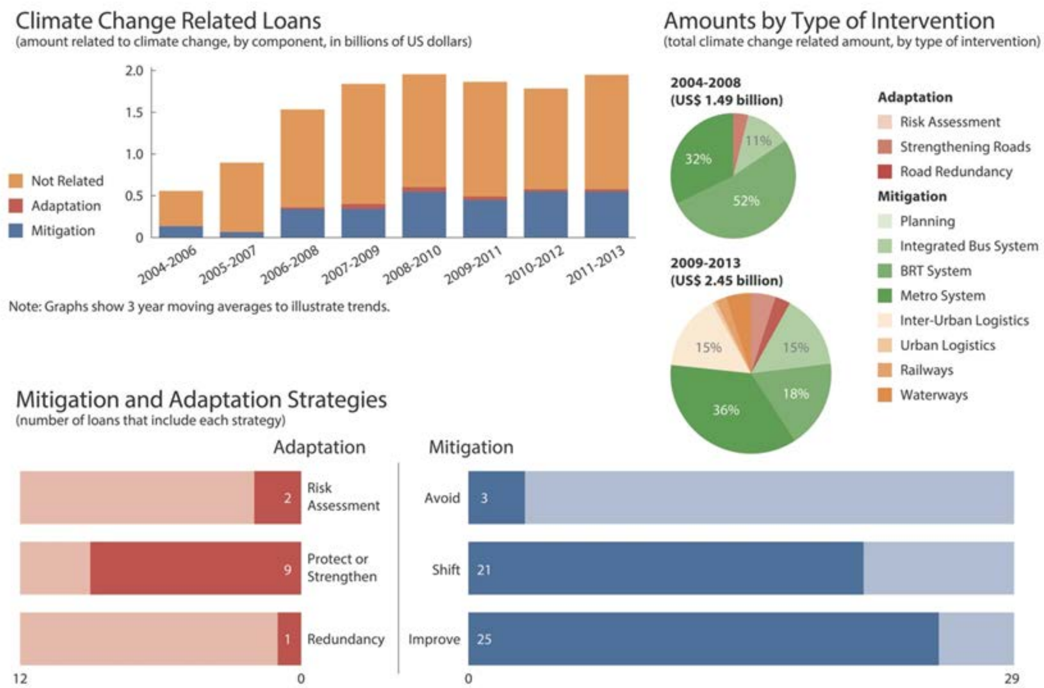
Source: OVE.

3.5 CC-related loans have mostly financed activities related to mitigation of GHG emissions (94%); adaptation interventions have received only 6% of the resources. Of the total CC-related lending, a little over 70% (19% of all lending) is for urban transport (including mostly mass transit and some logistics), with the remainder for interurban transport. In mitigation, the portfolio has expanded to include interventions that go beyond the initial set of BRT projects, such as improvement of traditional bus systems and multimodal integration of freight logistics projects that enhance the efficient use of existing infrastructure. A great majority of mitigation projects have included strategies to move toward more sustainable models or to improve technologies and systems. Only three of the interventions included measures to reduce dependence on cars by using the "avoid" strategy, via urban and land use planning.[57] Adaptation projects focused primarily on protecting or strengthening road and rail infrastructure by

[57] Transit-oriented development and land use planning to reduce demand for auto trips.

undertaking complementary works or by improving their technical specifications (see Figure 3.3).

Figure 3.3. Climate change loans: Types of intervention and strategies



Source: OVE.

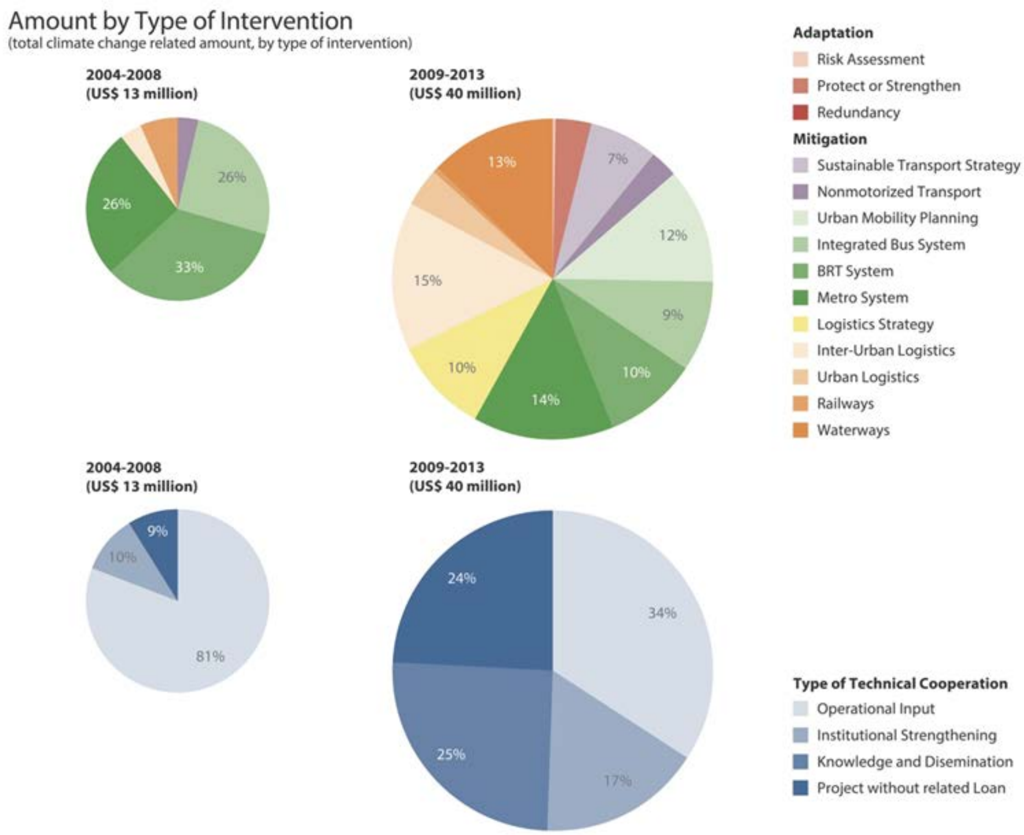
3.6 In addition to lending, the Bank has promoted its CC agenda in the transport sector through significant TC resources.[58] Of the 146 TCs approved in the transport sector between 2004 and 2013, nearly 50% in number (72 TC) and amount were directly or indirectly related to CC issues. Of the TC operations with explicit or implicit CC objectives, 92% financed activities related to mitigation of GHG emissions, mainly through urban mobility interventions; the adaptation-based TCs focused on strengthening road, rail, and sea transport infrastructure.

3.7 The TC portfolio reflects a wider range of interventions than the lending portfolio. It has evolved from being focused mainly on supporting urban transport operations to including planning for urban mobility, non-motorized transport, and the development of a sustainable transport strategy, as well as urban and interurban freight logistical projects and multimodal integration (see Figure

58 For a detailed description of the TC portfolio, see Annex I.

3.4).[59] With TC resources the Bank has supported logistical plans in 6 countries in the Region, urban mobility planning in 8, and mass transport systems in 17.[60]

Figure 3.4. Evolution of the TC portfolio, 2004-2013



Source: OVE.

3.8 During the period under evaluation, about half (48%) of the CC-related TCs provided Operational Input; they supported loan preparation (2/3 of this category) and loan implementation, mostly in the areas of passenger transportation and urban mobility (73%). This period was also characterized by a significant increase in projects related to knowledge generation (21% of approved CC-related TCs) and institutional strengthening activities (18% of the approved CC-related TCs). The knowledge TCs favored the dissemination of CC information through the creation of regional observatories or information systems, while the institutional strengthening TCs mostly focused on strengthening legal frameworks, supported

59 Between 2004 and 2008, 85% of the CC-related TCs supported mass public transport projects. Between 2009 and 2013, although the amount earmarked for public transport increased, it represented only 50% of the portfolio, and included planning and knowledge generation operations for a sustainable urban transport strategy.

60 The Bank has been active in including new kinds of projects, such as urban logistical centers or studies of the use of waterways for freight transport. TCs have also been used to promote policy and technical dialogue on matters of logistics and sustainable transport.

the process of negotiating public-private partnerships, and provided trainings to transport stakeholders.

3.9 A last category of the CC-related TCs (13%) financed "stand-alone projects" such as pilot projects for hybrid buses or project designs not related to a specific loan operation. They were mostly developed at the regional level (56%).

3.10 Overall, the CC-related TCs aimed at (i) developing logistical studies (logistics plans and platforms, urban logistics); (ii) developing methodologies for measuring GHG emissions and integrating the CC dimension into transport projects,[61] (iii) supporting regional dialogue on road and rail safety, low-carbon sustainable transport, and logistical challenges; (iv) facilitating private sector involvement in investments in the sector;[62] and (v) facilitating access to CC financing, such as the CDM and NAMA Facility.[63] Box 3.1 describes examples of CC-related TCs.

Box 3.1. Examples of CC-related TCs

Support for Regional Environmentally Sustainable Transport in LAC **(RG-T1848/RG-T1849) and *Support to REST Action Plan Plan* (RG-T1852).** These TCs, approved in 2010, sought to strengthen project planning and implementation capacities and to improve analysis of results of actions on GHG emissions. Outputs included the following studies: (i) *Climate Instruments for the Private Sector*, which evaluates the impact of the CDM, the World Environment Fund, and the CTF for the transportation sectors of developing countries; and (ii) *Mitigation Strategies and Accounting Methods for GHG Emissions from Transportation*, which reports on different methodologies for measuring GHG emission reductions.

Freight Transport and Logistics Regional Observatory **(RG-T1897).** Approved in 2011, this TC sought to develop a regional observatory on freight transport and logistics to generate much-needed information. The observatory was to build on synergies with other IDB initiatives linked to planning and developing freight and logistics plans and policies in different countries, and among the freight transport and logistics observatories that already existed at the national level. Simultaneously, this TC developed studies of the methodologies used to measure the cost of logistics and the transport-sector-related GHG emissions.

Support to the Energy Efficient National Freight Transport Initiative **(CO-T1237).** This TC, approved in 2011, sought to support the execution of the Program to Support the National Logistics Policy (CO-L1090), particularly those components linked to "Logistics Information and the National Observatory of Freight Transport and Logistics," "Logistic Services," and "Sustainable Logistics."

61 Publications in the transportation sector cover, among other things, lessons learned from the hybrid and electric bus pilot program, mitigation strategies and methodologies for measuring transportation-related GHG emissions, and a practical manual on car parking and policies for managing travel demand in LAC.

62 The Bank has supported the design of the public-private alliances needed for implementing rapid bus systems, in which public investment in infrastructure is complemented with private investment in modern, more efficient buses, and in the necessary operational structure for these transport systems.

63 TCs have supported applications for CDM financing in various Brazilian cities, as well as the preparation of a NAMA for freight transport in Colombia.

B. Bank action with regard to its commitments on climate change

3.11 The Bank has made several commitments and developed strategic documents to address CC concerns. The Ninth General Capital Increase (GCI-9) Agreement identified increasing investments in sustainable transport alternatives in urban and non-urban areas as a specific area for promoting sustainable development in LAC. During the Rio+20 meetings in June 2012, the IDB committed US$17.5 billion over a 10-year period to fund sustainable transportation (in both urban and non-urban areas).[64] As part of this agreement, the eight MDBs have developed a common framework for monitoring and reporting on sustainable transportation operations.

> **Box 3.2. Sustainable transport in IDB strategy documents**
>
> - **IDB Integrated Strategy for Climate Change, *Adaptation* and Mitigation and Sustainable and Renewable Energy (2011)**. The Climate Change Strategy calls for the Bank to develop instruments to mainstream climate mitigation in its operations, support comprehensive GHG reporting, and improve climate resilience in its projects. In transport, the strategy promotes a vision of sustainable transport oriented toward (i) reducing emissions by identifying and financing low-carbon, sustainable transport solutions for both passengers and freight, in both urban and rural areas, and (ii) strengthening the resilience of infrastructures and services.
> - **Sustainable Infrastructure for Competitiveness and Inclusive Growth – IDB Infrastructure Strategy (2013).** The strategy develops the concept of sustainability for all infrastructure sectors. It specifically proposes that the IDB prioritize actions to support the construction and maintenance of socially and environmentally sustainable infrastructure, thus enhancing quality of life.

3.12 The Bank's Climate Change Strategy (2011) and the IDB Infrastructure Strategy (2013) are aligned, as far as transportation is concerned, with the CC commitments under the GCI-9, as they both promote the adoption of sustainable transport (Box 3.2).

3.13 At the sector level, the extent to which CC concerns have been mainstreamed into strategic documents has been uneven. The CC Strategy recognized the importance of promoting sustainable low-carbon transportation solutions for passengers and freight, in both urban and rural settings. The transport sector incorporated this vision into its key strategic documents and sector framework, although with different emphasis. In the REST-Action Plan[65] the Bank further developed the notion of sustainable transport it had agreed on with other MDBs at Rio+20[66] and

[64] This commitment was made alongside seven other major Multi-Lateral Investment Banks; together the commitment is US$175 billion in total over the next decade toward Sustainable

[65] Updated Regional Environmentally Sustainable Action Plan 2013-2014.

[66] The Joint MDB Statement for Rio+20 defined sustainable transport as "transport that is accessible, affordable, efficient, financially sustainable, environmentally friendly and safe." Sustainable transport seeks to balance economic, social, and environmental/CC objectives in project design.

defined ways to incorporate it into its work[67] by adopting the *Avoid-Shift-Improve* model for all IDB-financed transport operations (roads, urban transport, freight and logistics). In contrast, while the sector framework document includes the promotion of efficient logistics networks, the lines of action in the sustainable transport dimension focus only on *urban* transport (see Box 3.3). Given that freight and interurban transport contribute about 50% of GHG and local pollutants in LAC, the failure to explicitly focus on lines of action to reduce emissions from freight represents a missed opportunity to strengthen the consideration of CC mitigation concerns in IDB operations.[68]

Box 3.3. Transport sector guiding documents

- **Draft Updated Regional Environmentally Sustainable Transport Action Plan (2013-2014).** The plan promotes decoupling of GHG and air pollutant emissions associated with transport from economic and social development. It adopts the *Avoid-Shift-Improve* model and calls for its application to all transport operations undertaken by the Infrastructure and Energy/Transport Division (INE/TSP).
- **Transport Sector Framework (2014).** The framework establishes that Bank actions will be aimed at strengthening the Region's transportation sector in an efficient, accessible, inclusive, sustainable, and secure manner, and focuses Bank activity on five main areas: (i) coverage, capacity, quality, and connectivity of transportation networks; (ii) cargo/freight logistics; (iii) sustainable urban transportation; (iv) regional integration; and (v) institutional development in the transportation sector.

3.14 The Climate Change Strategy called for the Bank to develop instruments to mainstream climate mitigation in its operations, support comprehensive GHG reporting and improve climate resilience in its projects. OVE found that progress in mainstreaming climate change in project design has also been limited to date for the reasons explained below.

3.15 The Bank, through its safeguards unit, ESG,[69] has developed a methodology for GHG accounting, which it applies to all Bank projects that produce significant quantities of GHG emissions. However, the methodology (Box 3.4) and its application have several shortcomings for transport projects—of which the most important is that emissions from the operation of vehicles used to build and

67 The Action Plan's main objectives include (i) mainstreaming CC issues in IDB operations and scaling up investments in low-carbon sustainable practices, and (ii) promote a co-benefits approach that integrates CC mitigation and adaptation with other economic, social, and environmental objectives.

68 The sector framework focuses on improving freight logistics, which would reduce transportation costs and thus increase the efficiency of goods movement, resulting in positive co-benefits in the form of reduced emissions of both local and global pollutants; however, the strategy does not highlight these co-benefits.

69 ESG developed the methodology for GHG accounting and started to track emissions in 2009. Lifecycle emissions are not calculated for biofuels; however, this is a small share of current total fuel usage for transport. INE/TSP calculates GHG emissions for countries that want to apply for climate financing.

maintain the road are calculated (Scope 1 and Scope 2), while those from the expected use of the road by general traffic are excluded (Scope 3).[70]

Box 3.4. GHG emission estimates, by scope

ESG calculates GHG emissions associated with construction and operation and maintenance in the first year. Estimates compare the project's Scope 1 and Scope 2 (construction and operations, assuming fixed demand) emissions to the business-as-usual (no project) scenario.

Scope definitions

Scope 1 measures direct GHG emissions from sources controlled or owned by the construction and operating companies of the transport project. It includes both emissions from the construction phase and emissions from the vehicles and materials used during the operation and maintenance of the roads. To estimate yearly emissions, total emissions during the construction phase are divided by 25 (average life of infrastructure projects) and added to the projected emissions of the operation of the first year.

Scope 2 measures the indirect GHG emissions resulting from the off-site generation of electricity, heat, or steam that is consumed by the project—for transport projects, the emissions caused by the electricity used during operation by lighting or other equipment powered by electricity.

Scope 3 measures the indirect GHG emissions resulting from the use of the transport infrastructure, like the vehicle traffic that uses a new or rehabilitated road. It can also include emissions from sources not owned or directly controlled by the reporting agency but related to the agency's activities.

Sources: EPA Website, accessed August 2014 (www.epa.gov); Breisinger, 2012.

3.16 ESG tracks GHG emissions to give an overarching view of the Bank's GHG emissions footprint and to be able to compare with other multilateral development banks. Emissions from projects greater than 25,000 tons of CO_2eq are reported in aggregate form by sector in the Bank's Annual Sustainability Report and to other multilateral development banks. However, this information is not used as effectively as it could be, as it does not inform project design.

3.17 Finally, the Bank has yet to define a clear policy on measuring and mitigating GHG emissions from the transport sector. As a result, it lacks a guiding policy on analyzing projects and alternatives vis-à-vis a "business-as-usual" scenario[71] that would encourage projects to analyze cost-effective options to achieve the same development objective while producing lower GHG emissions over the life of the project. This would require a significant strengthening of the methodologies used to estimate emissions for the sector, to account for such factors as possible

70 The current methodology is aligned with the accounting framework agreed to by a number of international financial organizations, including all major multilateral development banks (see International Financial Institutions Framework for a Harmonized Approach to Greenhouse Gas Accounting: http://www.worldbank.org/content/dam/Worldbank/document/IFI_Framework_for_Harmonized_Approach%20to_Greenhouse_Gas_Accounting.pdf). ESG is aware of the limitations of the methodology and is working with other multilateral development banks to incorporate Scope 3.

71 Although the Bank's safeguard policy addresses possible deforestation as an indirect impact of road building—which would lead to increased emissions (among other environmental impacts)—it lacks guidelines on mitigating direct emissions of GHGs from transport.

induced demand for travel on new or improved roadways. In defining such policies, it is critical to take a systemwide approach to the analysis of potential impacts of projects on GHG emissions

3.18 The results of the Bank's efforts to mainstream CC in the transport lending portfolio are limited: only 33% of transport loan operations (and 27% of lending) were related to climate change during the period evaluated, even though important TC resources were used to generate knowledge and demand in the Region. Nearly 50% (72) of transport TC operations were related to CC,[72] of which 22 were for project preparation.

[72] Most lending and TC operations are related to interventions that could reduce GHG emissions, with a limited number focused on strengthening the sector's adaptation to climate change.

IV. ASSESSMENT OF BANK TRANSPORT PROJECTS FROM A CLIMATE CHANGE PERSPECTIVE

4.1 To derive lessons learned from the Bank's lending portfolio that would be expected to have an impact, either directly or indirectly, positive or negative, on CC concerns (both adaptation and mitigation), the team conducted an in-depth analysis of 20 of the 125 transport projects approved between 2004 and 2013.[73] Because all transport projects can have an impact on GHG emissions, projects were divided into two categories to draw the sample:

(a) CC-related projects—that is, the 41 loans with either explicit or implicit mitigation or adaptation objectives. Of these, 18 (44%) were selected for review—8 with explicit and 10 with implicit objectives.

(b) All other projects—84 loans in total, mostly related to road construction and rehabilitation. Of these, 4 were included in the sample with a view to examining their potential impact on GHG emissions.

4.2 Because of time and resource constraints, the 20 projects chosen were not a statistically significant sample, but they were selected to provide a range of types of projects to illustrate key climate change issues in transport projects.[74] The sample included 7 urban mass transport projects (8 loans); 11 road, rail, or logistics infrastructure projects; and 1 institutional reform project (see Table 4.1). With the exception of the policy-based loan (PBL) in Colombia (*Program to Support the National Logistics Policy*, CO-L1090), all projects were investment loans. Of the 20, 2 were non-sovereign-guaranteed operations (*São Paulo Metro - Linhea 4*, BR-L1079, and *Rodoanel Oeste*, BR-1228). One project (*Metropolitan Urban Transport in Lima*, PE-0187), approved in November 2003 and completed in 2011, was included in the sample because of its direct relation to CC and the potential for analyzing results. The team visited 11 of the 20 projects.[75] Projects were analyzed in terms of their relevance, implementation, and results.

73 A random stratified sample was drawn to give a broad picture of a range of the Bank's lending portfolio, including a range of modes, CC objectives, and countries. Although the sample was random, the team adjusted it to include more loans in the two countries the team visited during evaluation missions (Colombia and Brazil).

74 Water transport and airports were not included because they represented a small share of the transport portfolio.

75 The team visited the nine projects in Brazil and the BRTs in Lima and Cali. The BRTs were visited as part of an ongoing evaluation on urban transport projects involving BRT.

Table 4.1. Project sample by objective and type of intervention

Climate change objective	Title/approval date	Type of intervention		
		Urban mass transit	Roads	Institutional reform
EXPLICIT – MITIGATION	Supplementary Financing for the Integrated Mass Transit System in Cali (SITM) (CO-L1101), 2011	BRT		
	Program to Support the National Logistics Policy (CO-L1090), 2011			Support the implementation of the national logistics policy
IMPLICIT – MITIGATION	Fortaleza Urban Transport Program (BR- 0302), 2004	BRT		
	Urban Transport Program for the Federal District (BR-L1018), 2008	Buses, train		
	Loan for the São Paulo Metro S.A. – Linhea 4 (BR-L1079), 2008	Metro		
	São Paulo Metropolitan Investment Program (BR-L1162), 2008	Commuter rail		
	Rodoanel Oeste (BR-L1228), 2009		Upgrade and expansion of SP beltway	
	São Paulo Metro Line 5 (BR-L1227), 2010	Extension Metro line		
	Rodoanel Mario Covas – Northern Section (BR-L1296), 2011		SP beltway	
	Santa Catarina Logistics Infrastructure Program (BR-L1336), 2012		Infrastructure logistics	
	Integrated Mass Transit System for Santiago de Cali (SITM) en Cali (CO-L1001), 2005	BRT		
	Metropolitan Lima Urban Transportation Program, North-South Subsystem (PE-0187), 2003	BRT		
EXPLICIT – ADAPTATION	Rural Connectivity Program for the Northern and Eastern Zones (ES-L1061), 2011		Rural	
	Transport Sector Support Program I (NI-L1049), 2010		Interurban	
	Transport Sector Support Program II (NI-L1052), 2012		Interurban	
	Transport Sector Support Program III (NI-L1071), 2013		Interurban	
	Flood Mitigation Infrastructure Program for Belize City (BL-L1013), 2011		Urban	
	Transportation Infrastructure Rehabilitation Program (JA-L1016), 2008		Interurban	
NO CC OBJECTIVE	Road Program for the State of Ceará - Ceará III (BR-L1181), 2009		Interurban	
	San Francisco – Mocoa Alternate Road Construction Project Phase I (CO-L1019), 2009		Interurban	

Source: OVE.

A. Mitigation of CO2 emissions in urban mass transport projects

4.3 Among urban transport projects, OVE reviewed four BRT loans (Cali, Lima, Fortaleza, and Cali supplementary), two metro lines in São Paulo (Line 4 and

Line 5), one commuter rail line in São Paulo (Line 9), and one mixed transport system in Brasilia (buses, train). The analysis sought to determine (i) whether projects clearly identified the issues contributing to GHG emissions from transport, and (ii) to what extent the interventions were appropriate for mitigating GHG emissions while also meeting the projects' main objectives. Although transportation projects include objectives that go beyond emissions mitigation—such as improving mobility or reducing travel times and costs—the relevance analysis presented here focuses on the elements of the operation that are related to CC mitigation.

1. Diagnostic and relevance of projects with respect to GHG emissions

4.4 The urban mass transport projects in the sample were relevant in their objectives. They generally sought to address such key urban mobility problems as oversupply of aging public transport vehicles, high levels of accidents, traffic congestion, and local and global emissions. Only one of the four mass transit projects (the second phase of the Cali BRT) had an explicit CC objective;[76] five other urban transport projects included reduction of GHGs among other pollutants as indicators in their results matrix, although they did not mention CC explicitly as an objective. Only four of the eight urban transit projects—the Cali and Lima BRTs and the two metro projects in São Paulo—included sufficient data or information to estimate the level of GHG emissions and establish a baseline from which to track progress and results.[77]

4.5 The second phase of the Cali BRT, the most recently approved BRT operation in the sample,[78] is one of the few LAC transport projects registered in the CDM to obtain credits for the reduction of CO_2 emissions. Not surprisingly, its design also had the highest-quality baseline and project scenario data collection process.[79] The diagnostic included a complete analysis of various critical factors that affect CO_2 emissions, such as an increase in the number of kilometers

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76 Although both the original and the supplementary Cali BRT loans had the same objectives and structure, only the supplementary loan included in its results matrix indicators related to CO_2 emissions reductions. The decision to improve Cali's transit system was not driven primarily by a desire for environmental improvement, but rather to provide a more efficient transport system that would, if implemented correctly, result in a decrease in emissions.

77 The documentation analyzed included loan documents, environmental and social studies, cost-benefit analyses, and monitoring and evaluation plans.

78 However, this loan never entered into force as it was not ratified by the Colombian authorities. The Government has decided to complete the second phase of the BRT with its own resources.

79 The MIO-SITM system was designed as an integrated mass transit system comprising three primary BRT trunk lines of 49 km in length and using 180 articulated buses. The total system was projected to carry up to 880,000 passengers per day, meeting 90% of public transit demand in the city (IDB, 2005; DNP, 2007). Several aspects of the design were relevant to reducing emissions of both global and local pollutants: (i) scrapping up to 80% of the old bus fleet, (ii) replacing old buses with fewer buses of primarily the Euro III type, (iii) achieving higher occupancy rates on buses, (iv) reducing bus km traveled by restructuring routes, and (v) improving vehicle operation speeds by providing exclusive bus corridors along the system's three trunk-lines.

traveled, types of vehicle technologies, the age of the transport fleet, and the type of fuel used.[80]

4.6 The other three BRT operations reviewed (Lima, Fortaleza, and original Cali)—all approved before the Bank developed its Climate Change Strategy—sought, in addition to improving mobility, to reduce transport-generated local pollutants (e.g., PM_x, NO_x, CO). Of these three loans, only the Lima project[81] included targets for reductions of CO_2 emissions.[82] For the Lima BRT, while the loan document did not present a strong analytical diagnosis of GHGs, a TC was designed to prepare an environmental baseline study of emissions of local and global pollutants attributable to the transport sector in the corridor of the project (Walsh and Deuman, 2005). The Fortaleza BRT loan document did not present sufficient information to clearly diagnose emissions.

4.7 The three projects in São Paulo were part of a master plan for integrated urban transport (*Plan Integrado de Transporte Urbano 2025*) designed by the Secretaria de Transportes Metropolitanos. All three mentioned possible reductions of CO_2 emissions as an important co-benefit, but only the two metro projects[83] included a full analysis of emissions and the factors behind them. In the metro projects, the quality of the analytic work appears to be associated with the institutional capacity of the executing agency, the São Paulo Metro company, and with the high standards required by the CDM mechanism, as both operations sought to apply for CDM registration.[84] This suggests that improving IDB's integration of transportation projects with climate finance may be an effective strategy for

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80 http://cdm.unfccc.int/Projects/DB/DNV-CUK1330665258.52/view

81 The Lima BRT aimed to improve mobility, particularly among lower-income groups, and to reduce the private, social, and environmental costs of the existing public transportation system. The project sought specifically to improve travel times, reduce air pollution by reducing emissions, modernize the transport system, formalize transport companies and workers, reduce the number of public transport vehicles through scrappage programs, and reduce the number of accidents involving public transportation. Project objectives relevant to CC included (i) reduction of fine particulate matter ($PM_{2.5}$) by 20%, and (ii) reduction of greenhouse gases (CO_2) by 15%.

82 GHG includes both CO_2 and environmental pollutants such as O_3 and black carbon. However, CO_2 is considered a global pollutant as it does not have immediate direct negative effects on human health (although indirectly, through its influence on climate at the global level, it does), and its impacts are global; by contrast, pollutants have local health effects.

83 The Metro Line 4 project, a non-sovereign-guaranteed loan, financed construction of a new metro line. It was structured as a public-private partnership program, under which the public sector was responsible for the construction of the civil works and the private concessionaire receiving the Bank's loan was responsible for the supply of rolling stock and systems and for operation and maintenance. The Metro Line 5 project financed upgrading of existing trains, systems, and equipment for the expansion of Line 5 with a view to improving mobility, connectivity, safety, and comfort for mass transit users.

84 Since 2005, the São Paulo Metro company conducts a regular inventory of the entire metro system and makes estimates of the emissions avoided as part of its Greenhouse Gas Emission Reduction Program. The Bank approved two TCs in 2008 to develop a CDM-accepted methodology to quantify and earn Certified Emissions Reduction credits as a result of the extension of and operational improvements to the Metropolitan metro and commuter rail system ((BR-T1098 and BR-T1107, respectively) in São Paulo. Both TCs were cancelled before implementation began.

improving the data collection and analysis conducted for projects with mitigation co-benefits or objectives.

2. Interventions to address GHG emissions in urban mass transport projects

4.8 In most mass transport projects, the Bank supported interventions that were geared toward improving the efficiency of existing systems or shifting the modal structure towards more sustainable modes. As Table 4.2 shows, most are supply-side interventions, mainly providing new or rehabilitated infrastructure and optimizing public service routes to improve public transportation and promote multimodal formats (i.e., pedestrian and bicycle routes). Some projects included measures to improve the vehicle and system technologies through scrapping old vehicles or upgrading them to higher emissions standards, optimizing routes, and using intelligent transport systems. By contrast, none of the interventions included demand-side measures aimed at, for example, reducing the number of single-occupancy motorized vehicle trips or reducing trip distances through such measures as transit-oriented development, land use planning, and transport pricing mechanisms.

Table 4.2. Intervention strategies: Public mass transport projects

Title and project code	Avoid (reduce car dependency)		Shift (promote modal change)		Improve (improve existing systems, new technologies)	
	Demand	Supply	Demand	Supply	Demand	Supply
Urban Transport in Lima (PE-0187) – 2003				· Public transport infrastructure · Multimodal integration · Infrastructure for pedestrians and cyclists · Policies to encourage private sector participation		· Optimization of public transport routes · Efficient vehicle technologies · Vehicle scrapping or decommissioning
Urban Transport in Fortaleza (BR- 0302) – 2004				· Infrastructure for pedestrians and cyclists · Public transport infrastructure · Multimodal integration	Fuel regulations*	· Infrastructure provision and maintenance · Optimization of public transport routes · Intelligent transport systems · Efficient vehicle technologies*
Cali Integrated Transport System (CO-L1001) - 2005 Supplementary Financing for the Cali Integrated Transport System (CO-L1101) - 2011			Public transport prices	· Public transport infrastructure · Infrastructure for pedestrians and cyclists · Policies to encourage private sector participation · Multimodal integration	Fuel regulations*	· Optimization of public transport routes · Intelligent transport systems · Efficient vehicle technologies · Vehicle scrapping or decommissioning
São Paulo Metro: Line 4 Project (BR-L1079) – 2008			Public transport prices*	· Public transport infrastructure · Infrastructure for pedestrians and cyclists · Policies to encourage private sector participation		· Optimization of public transport routes · Efficient vehicle technologies
São Paulo Metro: Line 5 Extension Project (BR-L1227) – 2010			Public transport prices*	· Public transport infrastructure · Infrastructure for pedestrians and cyclists · Multimodal integration		· Optimization of public transport routes · Efficient vehicle technologies
São Paulo Metropolitan Transport Investment Program (BR-L1162) – 2008			Public transport prices*	· Infrastructure for pedestrians and cyclists · Multimodal integration		· Efficient vehicle technologies
Urban Transportation Program for the Federal District (BR-l1018) – 2008				· Public transport infrastructure · Infrastructure for pedestrians and cyclists · Multimodal integration		· Optimization of public transport routes · Intelligent transport systems · Efficient vehicle technologies*

* Indicates measures adopted by government authorities but not necessarily included/promoted by IDB projects.
Source: OVE.

4.9 Some complementary interventions that would be expected to support the project's sustainability goals[85] were implemented at the state or municipality level by client governments. For example, the Government of Brazil adopted fuel quality standards with the potential for significant CO_2 emissions reductions.[86] This was the result of government plans and policies, and it is not possible to determine to what extent the Bank might have contributed to the change. However, since Bank projects finance mostly infrastructure, projects often do not include demand-side measures as part of their design.

3. Implementation and monitoring in urban mass transport projects

4.10 Of the eight urban mass transport projects reviewed, all but the two metro projects have experienced important execution delays, which can ultimately compromise achieving GHG and local pollutant emissions reductions. Delays were found to be due mostly to the complexities associated with undertaking large-scale infrastructure works in often dense and long-established urban areas, and to the difficulty of implementing timely complementary measures to support interventions from the demand side. For the Cali BRT, for example, the final trunk road of the BRT system has experienced significant delays because the project affected nearly 1,000 properties.

4.11 The scope of at least two projects in Brazil was significantly reduced,[87] compromising the coherence of the interventions and, as a result, their ability to generate emissions reductions. For the Fortaleza BRT, two of the three BRT corridors originally envisaged and investments in public space and pedestrian connections were cancelled because of cost overruns and a shift in municipal government priorities.[88] In the Transport Program for Brasilia, because of delays and cost overruns the project's scope was reduced to road improvements. Important components related to the public transport management system and a control center were not implemented.

4.12 Mechanisms to monitor and report on emissions were weak in most of the eight urban mass transport projects reviewed. Except for the Cali supplementary loan and the metro projects, all loans with implicit CC objectives have insufficient mechanisms to effectively track and report on CO_2 emissions. Of the projects that

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85 *Demand-side interventions* are measures that encourage travel and consumer behavior in a manner that would be expected to reduce emissions—for example, pricing mechanisms to encourage modal shifts, the uptake of low-carbon technologies (e.g., fuel-efficient vehicle technologies), or travel at different (less congested) times of day or along less congested routes. *Complementary measures* are those that might support a particular investment and could be either supply- or demand-side. For example, providing bike parking at transit stations is a supply-side measure to encourage access to stations by sustainable modes (rather than by private vehicles).

86 However, the Government has also adopted policies that make it easier to buy private vehicles, increasing the level of activity and, as a result, of GHG emissions.

87 Delays between loan approval and the beginning of works and fluctuations in the exchange rate were reported as reasons to reduce the scope of these projects.

88 To be ready for the FIFA World Cup, the Federal Government financed the remaining corridors with its own resources.

include CO_2 emissions-related indicators, only two included a detailed description of the monitoring methodology in their monitoring and evaluation plan. Of the four urban transport projects that are fully disbursed,[89] neither of the two Project Completion Reports (PCRs) reported on the reduction of GHG emissions achieved (see Box 4.3).

Box 4.3. Monitoring systems in urban transport loans

Eight Urban Mass Transit Loans

- **Loans with explicit climate change objectives:** CO-L1101
- **Loans with implicit climate change objective—a co-benefit:** 7
- **Loans including indicators and targets to track CO_2 emissions:** 5
  - Supplementary finance for the Cali Integrated Transport System (CO-L1101)
  - São Paulo Metro – Line 4 Project (BR-L1079)
  - São Paulo Metro - Line 5 Extension Project (BR-L1227)
  - Urban Transport in Lima (PE-0187)
  - Cali Integrated Transport System (CO-L1001)
- **Projects with monitoring system to track CO_2 emissions:** 2 of 5 projects with emissions-related indicators:
  - Supplementary finance for the Cali Integrated Transport System (CO-L1101)
  - Cali Integrated Transport System (CO-L1001)
- **Fully disbursed projects (4) that had PCRs (2) that reported emissions reductions:** 0 of 2

4. Results: CO_2 emissions in selected mass transport projects[90]

4.13 OVE estimated CO_2 emissions for four of the public transport projects, three of which were fully disbursed and in operation—Lima BRT, Cali BRT-Masivo Integrado de Occidente (MIO), and São Paulo Metro Line 4—and one that was under implementation (São Paulo Metro Line 5). Box 4.4 briefly describes the methodology used for these calculations, and Table 4.3 shows the results for the Cali and Lima projects. A full description of the methodology is provided in Annex II.

89 Metro Line 4, São Paolo Metropolitan Train, Lima BRT, and Cali BRT.

90 Results were analyzed mainly from a climate change perspective, focusing on the extent to which projects had achieved or were likely to achieve CO_2 emissions reductions. This analysis was limited to projects with sufficient information to estimate CO_2 emissions.

Box 4.4. Methodology for estimating CO2 emissions

OVE used a top-down first-order approximation to estimate CO_2 emissions in Bank projects. For mass public transport, the following variables were analyzed: (i) number of passengers, (ii) modal change, and (iii) number of passengers per kilometer traveled, or kilometers traveled per vehicle type. For road infrastructure projects, the following variables were analyzed: (i) projected traffic (broken down by vehicle type), and (ii) level of improvement of road surface according to the International Roughness Index, if applicable.

For completed (fully disbursed) projects, OVE estimated the change in CO_2 emissions comparing the with-project situation to the without-project situation, year by year throughout the project's lifetime.

For projects under implementation, OVE conducted ex ante analysis of the potential impact in terms of CO_2 emissions reductions to be generated as a result of the project. Given the complexity of isolating the specific effects generated by the Bank-financed components, the analysis considered the whole project and not just the components financed by the IDB.

4.14 The Cali BRT project achieved significant emission reductions between 2008 and 2012 (41-46% relative to the baseline), after the MIO became operational. Reductions stemmed from the scale of the project (the project attempted to reform nearly the entire public transport system and meet 98% of the demand), rationalization of the vehicle fleet, and reform of the bus system. Restructuring of routes resulted in fewer bus kilometers traveled to serve the same trips. Moreover, to date 3,851 buses have been scrapped and replaced by new buses that meet Euro III emissions standards, and both Euro IV and Euro V vehicles have been introduced into the fleet (Steel Davies Gleave, 2013).[91]

[91] The main driver for these technology improvements was compliance with updated national emission standards (Resolución 2604 of 2009), which since 2010 requires emissions of all new buses to be equivalent to Euro IV.

Table 4.3. Emission reduction calculations for BRT projects

<table>
<tr><th>Methodology/assumptions</th><th>Estimated CO_2 emission reductions</th><th>Conclusions</th></tr>
<tr><td>

Cali Integrated Transport System - MIO (CO-L1001)

- Emission factors in g/kms.
- Activity factor by vehicle type.
- Base scenario: extrapolation of current situation without change
- Project scenario: modal change from buses and cars to MIO.
- The optimistic scenario assumes more kilometers traveled by the traditional bus system than the pessimistic scenario; it also assumes continued growth of the new bus fleet after 2012, which the pessimistic scenario keeps constant.

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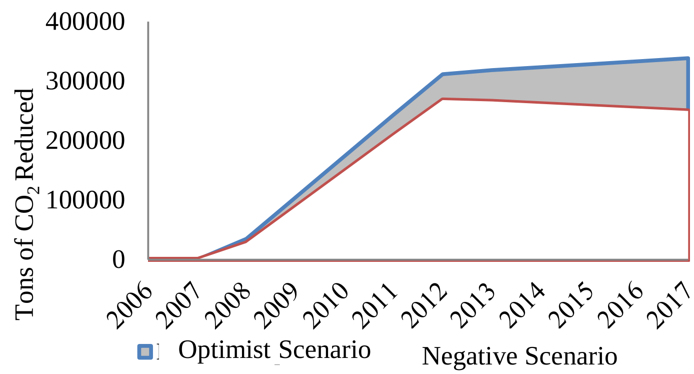

Source: Clean Air Institute & OVE.

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Significant reductions of CO_2 emissions—41-46% below the baseline—were achieved between 2008 and 2012, when the MIO BRT became fully operational. Savings resulted from modernization and rationalization of the fleet and restructuring of routes.

However, CO_2 emissions reductions have been hindered by execution delays and problems with the financial sustainability of the private bus operators, an undersupply of buses, a resurgence of the informal sector, and incomplete scrapping of old buses.

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Urban Transport in Lima (PE-0187)

- Differences between scenarios A and B reflect uncertainty on the passenger per kilometer index of the traditional bus system. Scenario A uses 1.59, and Scenario B uses 1.62.
- Scenarios C and D reflect changes to the base scenario. C assumes the traditional bus fleet won't change over time, while D assumes changes in the bus fleet and increased fuel efficiency of the traditional buses.

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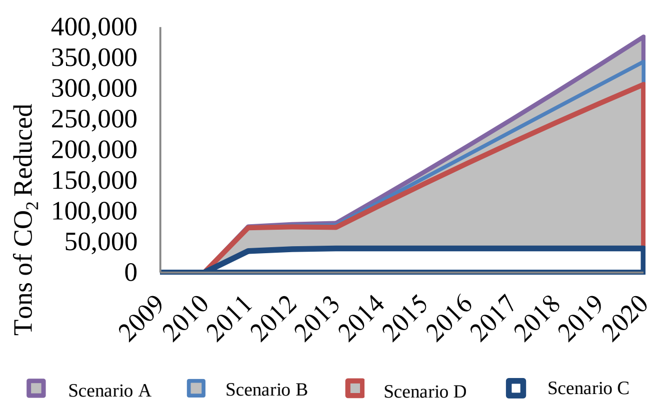

Source: Clean Air Institute & OVE.

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The BRT system in Lima has achieved CO_2 emissions reductions in its corridor (as well as reductions in black carbon and PM_x) between 2011 and 2013. The annual average reduction of CO_2 emissions was between 185,500 and 226,000 tons (between 2010 and 2020). Average yearly emission reductions for $PM_{2.5}$ are expected to range between 243 and 288 tons and for black carbon between 130 and 154 tons per year. In 2013, CO_2 emissions reductions achieved are from 80,500 to 121,400 tons (a 3.3-5% reduction at a citywide level).

Emissions reductions were hindered by delays in the bus scrapping program and ongoing competition with the system from the traditional bus companies. Lima has scrapped approximately 25% of the buses targeted for scrapping as of May 2014.

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Note: Graphs depict the estimated and projected range of CO_2 emission reductions.

4.15 Several issues remain that may affect both the ability of the Cali BRT system to address increasing transport needs and the sustainability of CO_2 emission reductions. Although significant progress has been made on vehicle scrapping (82% of targeted buses), old, highly polluting buses remain in service (Steer Davies Gleave, 2013). The city has yet to finish negotiations with the transport sector regarding full decommissioning of obsolete buses, which continue to circulate and generate GHG emissions and other local pollutants. Moreover, because of the slow progress of the infrastructure construction, the system is not fully operational. The east-west corridor is in the last phase of construction and is still not completed. There are also fewer new buses in circulation than anticipated.[92] The executing agency reports that the bus companies have withdrawn some buses from service in response to financial difficulties. This has contributed to overcrowding and long wait times on the new system and a resurgence of the informal bus sector to fill in underserved routes. Moreover, ridership was 45% of the projected figure in 2012, and the private car trips forgone in favor of bus transportation were half the expected number. [93]

4.16 The BRT system in Lima[94] achieved CO_2 emissions reductions (as well as reductions in black carbon and PM_x) between 2011 and 2013 as a result of the gradual implementation of the system. After 2013, CO_2 emission reductions are expected to continue over time. A key contribution of the IDB loan was the funding of an alternative fuels study to determine the economic feasibility of using cleaner fuels in the buses. The analysis found that CNG was the most cost-effective option, given the local price of the fuel and the availability of natural gas from the CAMISEA pipeline investment. It further concluded that the CNG buses using Euro III technology would have substantially lower annual emissions of particulate matter, NO_x, and SO_2, as well as lower CO_2 emissions.

4.17 However, emissions reductions were hindered by delays in the bus scrapping program and ongoing competition with the system from the traditional bus companies.[95] Instead of scrapping old buses, the municipality initially decided to relocate them to other areas of the city, where their use could ultimately offset any potential reduction in GHG emissions achieved by the project. To date, approximately 25% of the targeted traditional bus fleet has been scrapped.

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[92] In 2013 there were 897 buses operating (Steer Davies Gleeve, 2013), against the original planned number of 1032.

[93] Ridership was 92 million rather than 206 million during the monitoring period, and 2% of private car trips were forgone in favor of bus trips, rather than 4% (CDM, 2013).

[94] The project consisted of a single exclusive corridor, 27 kilometers in length, which carries high-capacity articulated buses and is served by several feeders in the north and south cones. Crossing 16 districts, it was designed to connect the north-south cones to the city center. It serves 4.5% of the daily trips in public transportation in Lima, with the remaining 95% covered by the traditional bus service of combis, coasters, and buses, and 0.5% covered by an electric train. Pre-investment studies estimated that passengers per day on the BRT trunk corridor would reach 534,000, and, with the inclusion of the feeder routes, ridership could reach 713,000 per day (Macro Consult, 2005).

[95] As of February 2014, Lima's *chatarreo* program had scrapped 1,680 vehicles from a target of 6,470, or 26% of the target (Protransporte, 2014).

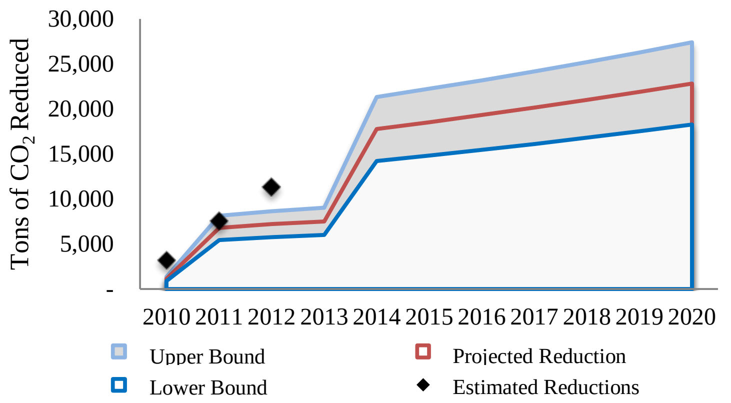
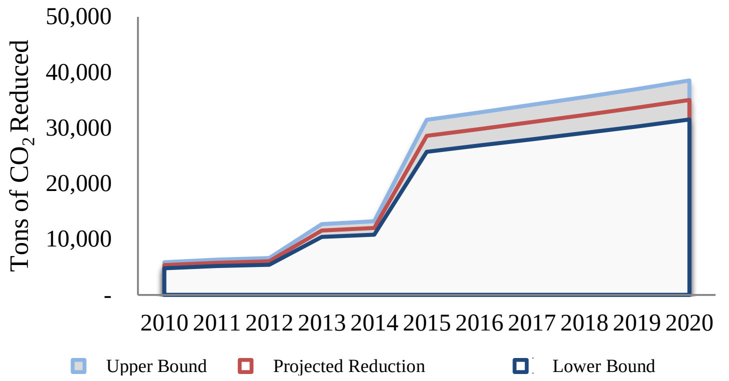
Measures to address these issues were not part of initial project design. In addition, the northern bus yard is 7 kilometers from the northern BRT terminal; buses travel this distance without passengers, reducing the overall efficiency of the system.

4.18 The two metro lines in São Paulo were also found to have significant CO_2 emission reductions (see Table 4.4). Both completed important links in the metro network, lowering travel times and capturing a significant amount of latent demand for passenger trips (inducing mode shifts—mainly from buses, but some from cars), and applying energy efficiency and green measures to the operation of the lines,[96] which saved emissions. However, from interviews with executing agencies, it was unclear what happened to the old buses that had served the route served by the new metro Line 4, which could potentially represent a source of leakage with respect to net emissions reductions.[97]

96 For example, Line 4 in São Paulo included a braking system that generated energy that could be stored and used as electricity, thus saving emissions.

97 For example, if these bus routes are still in operation but are operating at less than capacity because of a modal shift from the buses to the metro, the emissions would still be occurring from these trips.

Table 4.4 Emissions reduction calculations for metro projects

Assumptions	Estimates	Results
São Paulo Metro - Line 4 Project (BR-L1079) • Emission factor for each mode in grams/passenger [a] • Demand for metro switched from car (14%) and from bus (76%)[b] • Demand calculated for Line 4 only (supposed to correspond to modal shift, i.e. passengers switching from both car and bus to metro)		Emission reductions exceeded expectations as a result of greater demand than originally estimated. It was unclear, however, what happened to the old buses from which passengers shifted (i.e., to what extent these older and more polluting vehicles are still running in the city).
São Paulo Metro - Line 5 Extension Project (BR-L1227) • Emission factor for each mode in grams/passenger [a] • Demand for metro switched from car (14%) and from bus (76%)[b] • Demand from only new passengers of Line 5, without transfers		This project is still under implementation. Estimates indicate potential savings in CO_2 emissions that will increase over time.

[a] Inventario de Emisiones de São Paulo. Observatório de Movilidad Urbana – CAF, 2010.

[b] Plano Setorial de Transporte e Mobilidade Urbana para Mitigacão e Adaptacão a Mundança do Clima, 2012.

Note: Graphs depict the estimated and projected range of CO_2 emission reductions. For projects for which data were available, the points indicate estimated levels of CO_2 emission reductions.

4.19 In summary, the urban transport projects analyzed here all contributed to important reductions in global and local emissions through a combination of factors such as provision or expansion of modernized transit systems, which in most cases included to some extent pedestrian and bikeway facilities, vehicle scrapping, route optimization (in the case of the BRT systems), and improvements in vehicle technologies and fuels. However, several issues limited these gains for the BRT projects, including lack of political will to remove obsolete transit vehicles, design flaws in contractual arrangements with private bus operators, financial sustainability issues experienced by bus companies, and implementation delays. For metro Line 4, emissions reductions from the new line exceeded what was expected. However, it was unclear what happened to buses that used to serve the trips now provided by the metro and their associated emissions. In addition, none of the projects included "avoid" strategies such as land use planning around stations and parking polices, which could have strengthened their emissions mitigation impact.

B. Mitigation of CO_2 emissions in road and infrastructure logistics projects

4.20 The team reviewed three interurban roads projects (*San Francisco-Mocoa Alternate Road*, CO-L1019; *Ceará III Road Program*, BR-L1181; and *Santa Caterina Logistics Infrastructure Program*, BR-L1336) and two operations for the metropolitan beltway of the city of São Paulo (*Rodoanel Oeste* and *Rodoanel Norte*). This group includes the only two projects of the sample with no explicit or implicit CC objectives (San Francisco-Mocoa and Ceará III).

1. Diagnostic and relevance of projects with respect to GHG emissions

4.21 The roads projects reviewed were relevant to the extent that they sought to address key transport challenges related to the need to connect productive zones with consumer and distribution areas, and extend and/or improve road and network conditions to reduce travel times and costs. From a climate change perspective, three projects identified emissions reductions as an important co-benefit, and all three included information to diagnose the current level of CO_2 emissions and establish a baseline. Both Rodoanel projects presented in-depth analyses of GHG emissions,[98] although with shortcomings (see Box 4.5).

98 Inventory of the Western section and the Environmental Impact Study for the Northern.

Box 4.5. Diagnostic limitations: Rodoanel Oeste and Norte

The Rodonael projects sought to avoid the circulation of trucks through São Paulo (Marginal Tieté and Marginal Pinheiros) by improving and building the beltway. Emissions reductions were estimated for Marginal Tietê and Pinheiros, which would receive less traffic as freight traffic switched to the Rodoanel, as an approximation to the increase in air quality in the area. Although useful for determining the effects on local emissions, the diagnostic did not include the emissions that would be generated by vehicles using the new road. Moreover, estimates of CO_2 emissions failed to consider the effects of induced traffic on the new Rodoanel, based on the assumption that the capacity of the road can be increased to meet demand. It is possible to maintain service levels by increasing the number of lanes, but space is limited, and the road also interacts with the city streets that serve as access and exits to the beltway. Finally, emission factors are different for both sections. While Rodoanel Norte uses emission factors from IPCC, Rodoanel Oeste uses factors that are considerably above IPCC's, resulting in greater emissions savings (Rodoanel Oeste used emission factors of around 8.8 Kg of CO_2/gallon of fuel, while Rodoanel Norte used factors of 4.5 Kg of CO_2/gallon of fuel.)

4.22 The Santa Catarina Infrastructure Logistics Program included a diagnostic of the CO_2 emissions for each section of road to be upgraded and estimated emission reductions per type of intervention.[99] It provides the best example of the trade-offs that can occur between a project's proposed aims of improving mobility and simultaneously reducing CO_2 emissions (see Box 4.6). There were slight reductions in projected CO_2 emissions compared to the business-as-usual scenario; however, the main objective of the project was to improve the efficiency of goods movement in major freight corridors and reduce accidents related to hazardous waste spills. Achieving greater reductions would have required a greater focus on modal shifts, fuels, and vehicle technologies.

99 Using HDM-4, emissions were estimated according to fuel consumption, vehicle type, and operating speeds, which can vary according to the roughness of the road surface, the road geometry, and the level of service.

Box 4.6. Santa Catarina: Trade-offs between goals

The project sought to improve the state's road infrastructure, as well as road safety and environmental conditions (reducing emissions), through the construction and rehabilitation of roads. Ex ante estimates indicated, however, that in some cases the level of emissions would in fact rise with respect to the base scenario, although less than without the project in the short run.

[Ton CO_2 eq.]	Base year (2011)	Future scenarios without project (2015)	Future scenarios with project (2015)
New roads	575,000	622,000	588,000
Road resurfacing	2,856,000	3,201,000	3,149,000
Road rehabilitation	144,000	163,000	163,000

The increase would be less than in the scenarios without projects, particularly for road resurfacing and construction of new roads, in which the reductions with respect to a with-project scenario are estimated at 2-5%. For the rehabilitated sections, the emissions level remains constant and may even increase in time with respect to the base scenario, given induced demand.

Source: IDB 2012b

2. Implementation and results in road infrastructure projects[100]

4.23 Implementation in the projects analyzed has not been an issue. Of the five projects analyzed, none experienced delays that required extensions. Two were closed on time (Ceara and Rodoanel Oeste), and the others are scheduled to close as planned. Projects included mechanisms for efficient monitoring and reporting of CO_2 emissions results (see Box 4.7).

Box 4.7. Monitoring systems in road project loans
Five Road Projects in Brazil

- **Loans with explicit climate change objectives:** none
- **Loans with implicit climate change objective—a co-benefit:** 3
  - Rodoanel Oeste (BR-L1228)
  - Rodoanel Mario Covas Project - Northern Section (BR-L1296)
  - Santa Catarina Logistics Infrastructure Program (BR-L1336)
- **Loans including indicators and targets to track CO_2 emissions:** 3 (same as above)
- **Projects with monitoring system to track CO_2 emissions:**
  - Rodoanel Oeste (BR-L1228)
  - Rodoanel Mario Covas Project - Northern Section (BR-L1296)
- **Fully disbursed projects with a PCR that reported emissions reductions:**
  - Rodoanel Oeste (BR-L1228)

100 Results were analyzed mainly from a CC perspective, focusing on the extent to which projects had achieved or were likely to achieve CO_2 emissions reductions. This analysis was limited to projects with sufficient information to estimate CO_2 emissions.

4.24 For an assessment of results, OVE estimated emissions for one fully disbursed project (Rodoanel Oeste), and three operations under execution (Rodoanel Norte, the San Francisco-Mocoa Alternate Road and the Santa Catarina Logistics Infrastructure Program).[101] Table 4.5 shows the results for the Rodoanel Oeste and San Francisco Alternate Road.

[101] For completed (i.e. fully disbursed) projects, OVE estimated the change in CO_2 emissions, comparing the with-project situation to the without-project situation, year by year throughout the project's lifetime. The graphs in Tables 4.4 and 4.5 show the projected range of CO_2 emission reductions. The points indicate actual levels of CO_2 emission reductions. For projects under implementation, OVE conducted ex ante analysis of the potential impact in terms of CO_2 emissions reductions generated as a result of the project. Given the complexity of isolating the specific effects generated by the Bank-financed components, the analysis considered the whole project and not only the components financed by the IDB.

Table 4.5 Emission reduction calculations for road infrastructure projects

<table>
<tr><th>Assumptions</th><th>Results</th><th>Conclusions</th></tr>
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Rodoanel Oeste (BR-L1228)

- Real traffic broken down according to light (gasoline) and heavy (diesel) vehicles.
- Function that relates speed with consumption and emissions, broken down into gasoline and diesel.
- Speed of vehicles without project assumed to be the average speed in the city.
- Speed with project for light and heavy vehicles of 80 and 60 km/h respectively.

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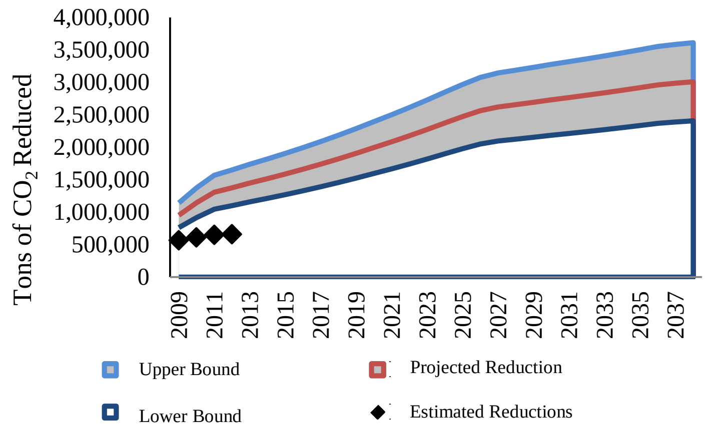

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Significant benefits have been achieved up to the present, but 50% less than was estimated ex ante, according to OVE's own calculations, based on real traffic levels on the alternate road and on relationships between operating conditions, fuel consumption, and CO_2 emissions.

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Construction of San Francisco - Mocoa-Alternate Road Program, Phase I (CO-L1019)

- Emission factor by vehicle and kilometer.[a]
- Traffic diverted to alternate road and projections (INVIAS).
- Reduction in kilometers driven by diverted traffic.

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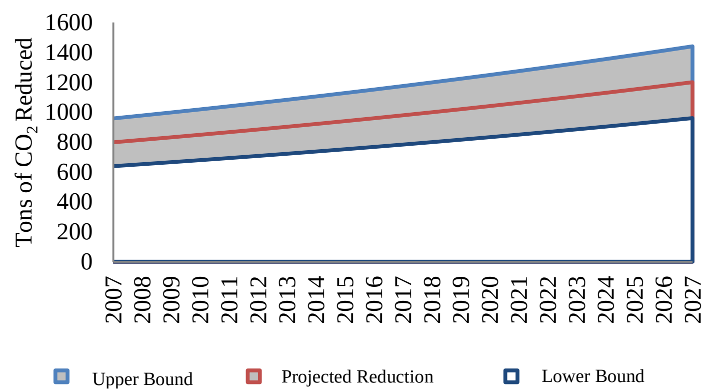

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The project is still under implementation. Ex ante estimations show CO_2 reductions due mainly to transport activity (kilometers traveled), better operational conditions (state of roads), and the fact that there is no foreseeable significant increase in traffic.

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[a] Ten Year Air Decontamination Plan (Plan Decenal para la Descontaminación del Aire de Bogotá), 2010.

4.25 In summary, several of the roads projects in the sample (3 of 5) are expected, or appear, to have improved driving conditions, and the two that were analyzed for emissions impacts were found to have reduced emissions (relative to the business-as-usual scenario) in the short term, but the long-term implications are uncertain. When vehicle congestion levels are high, projects that increase the road network's capacity, such as the São Paulo metropolitan beltway, can improve driving conditions and shorten travel distances for a significant number of private vehicles and freight carriers. However, the medium- and long-term effects of these projects are not so clear. Planners tend to underestimate the induced traffic from these improvements, and to overestimate how long this additional capacity will be able to maintain optimum service levels.[102] The availability of new roads generates pressure to urbanize the surrounding areas, the increase in traffic will continue until it reaches the previous levels of congestion, and the capacity of the road network cannot be increased indefinitely to maintain traffic flow levels. Furthermore, the bottlenecks might not just be located in the section that is being continuously extended, but rather in the local roads that serve as motorway exits. All the emissions reductions achieved by the original project can end up being offset when the service levels begin to decline, and the number of vehicles circulating through the network is much higher than before the project. The Rodoanel's sustainability over time will be limited unless complementary measures are put in place to promote transport inter-modality, and aspects of integral demand management are added. In Santa Catarina, enhanced connectivity and improved roads will lead to an increase in the level of CO_2 emissions over time as traffic increases (as, in fact, the results matrix shows).

4.26 Studies also have shown that when new roads are located close to forests, they can have indirect effects on land use, facilitating deforestation and expansion of agricultural boundaries (Reymondin et al., 2013). For the Pasto-Mocoa road, the impact studies failed to consider sufficiently the fact that the new route was going to induce higher travel demand. Furthermore, the mitigation plans were limited to only the section of road being built and did not take into account the cumulative impacts of various sections of road together. Although the Bank activated the required environmental protection measures for a project developed in a sensitive area, there is uncertainty about the definition of the areas directly and indirectly affected by the project, and the quantification of the project's negative impacts. When assessing these kinds of projects, it is necessary to evaluate the risks that the investment will result in deforestation and changes in land use that can increase CO_2 emissions.

[102] The increase in traffic may continue until it reaches the previous levels of congestion, and the capacity of the road network cannot be increased indefinitely. The availability of new roads may generate pressure to urbanize the surrounding areas, and the possibility to keep on adding the additional road capacity that would conserve traffic flow levels is uncertain.

C. Emissions in institutional reform projects

4.27 The only policy reform project reviewed in the sample is the *Program to Support the National Logistics Policy in Colombia* (CO-L1090), approved in 2011. This is a relevant and innovative program aimed at reducing the country's transport logistics costs and import and export times through policy actions that support implementation of a National Logistics Plan. The program is supported by a PBL, various TCs, and a TC loan that addresses important key climate change issues.[103] The loan's overall climate change objective is to develop policies that reduce the contribution of GHG emissions from the freight sector. To this end, specific objectives include (i) the promotion of policies to encourage alternative and presumably lower-carbon modes for freight movement (e.g., rail and water), as well as "technological, operational, and regulatory improvements in road freight"; and (ii) development of a national action plan to promote eco-driving and general sustainable transport measures.

4.28 The project diagnosis provides the overall dimension of the problem of GHG emissions from freight in the country, stating that it contributes 50% of the total from transport (21.8 Mt CO_2eq total, or 10.5 Mt CO_2eq from freight, in 2004). However, the diagnosis does not disaggregate the emissions by freight modes and fails to consider the underlying factors that contribute to these high emissions from freight (modal shifts, relative efficiencies of the modes, fuels, emissions standards, age of vehicles, etc.)—information that would be critical in developing solid policy design. One of the TCs associated with the PBL is intended to finance a methodology and to develop a data observatory for measuring GHG emissions from freight transport.

4.29 While the policy conditions of the PBL provide important institutional strengthening measures related to logistics—which by itself can set the stage for the implementation of measures that contribute to emissions reductions by increasing efficiency—the specific measures in the results matrix do not necessarily generate the strong policy changes needed to achieve long-lasting and significant reductions in emissions. Specifically, the PBL requires a study on the feasibility of increased use of waterways for freight, and one on an increase in the menu of projects that would be eligible for NAMA (see Box 4.11) and GEF financing.[104] If the study in fact leads to the substitution of waterways for freight transport over roads, this could lead to emissions reduction. While the goal of increasing the number of green freight projects is laudable, it is not clear what the scale and replicability of projects would be; and the benefits, while positive, would have possibly small and isolated impacts (especially since the scale of projects or emissions benefits are not specified in the PBL). Moreover, this

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103 The Bank has financed (i) CO-T1237, to develop a methodology for measuring freight transport emissions and defining mitigation measures; (ii) CO-T1229, to develop a NAMA action plan; (iii) CO-T1238, to prepare a study of alternative modes of freight transport using river courses; and (iv) CO-T2219, to draft a strategy for promoting the widespread use of bicycles.

104 The PBL policy conditions include, among other things, institutional strengthening for freight logistics management, establishment of information systems, and studies and policy guidelines.

approach in a PBL misses an important opportunity to encourage actual policy reform that would have wider and more systematic impact on emissions, such as improved vehicle emissions standards for heavy- and medium-duty trucks, economic incentives for modal shifts, or adoption of advanced technologies that would be expected to reduce emissions and change behavior.

Box 4.11. ***National Freight Transport Plan: NAMA Pilot Study*** **(CO-T1229)**

The Bank helped in preparing a pilot study to design a freight transport NAMA for Colombia. The NAMA proposal was integrated into the National Logistics Policy (CONPES 3547) (Política Nacional Logística), approved by the Colombian Government as a way of shifting toward more sustainable forms of transport. This study includes feasibility studies and estimates of emissions impacts and associated co-benefits; it also promotes public consultations on the issue of sustainable transport; defines a suitable institutional framework for the NAMA; defines the methodological requirements for developing the measurement, reporting, and verification programs; and identifies financial needs.

With the NAMA, GHG emissions are estimated to be 35% less than without a national logistics plan. Moreover, savings of around US$159 billion are estimated for 2012-2040, mainly in reductions in fuel consumption due to a 5% reduction in journey distances.

D. Climate change adaptation projects

4.30 The Bank's activity on adaptation to CC in the transport sector lags behind its work on emissions mitigation. Of the 125 projects approved, only 10% (12 projects) address adaptation. The resources devoted to adaptation components add up to only 1.6% of the financing for the sector as a whole. Half of the adaptation projects have explicit objectives to reduce infrastructure vulnerability and/or transport services, and the rest are projects classified as having implicit CC objectives because the project documentation incorporates the CC dimension into the reconstruction or rehabilitation works.

4.31 OVE analyzed all projects with explicit adaptation objectives approved from 2003 to 2014 (see Table 4.6).[105]

[105] The three operations in Nicaragua (*Support to Transportation Sector I*, NI-L1049; *Support to Transportation Sector II*, NI-L1052; Support *to Transportation Sector III*, NI-L1071) are all part of the same program and have therefore been analyzed as a unit.

Table 4.6 Projects with explicit adaptation to climate change objectives

Title/code	Year of approval	Amount approved (US$ million)		% disbursed
		Investment	Related TCs	
Flood Mitigation Infrastructure Program for Belize City (BL-L1013)	2011	10.0	BL-T1018	19.0%
Rural connectivity program for the northern and eastern zones (ES-L1061)	2011	15.0	ES-T1132	30.0%
Support to Transportation Sector I (NI-L1049)	2010	18.2		98.8%
Support to Transportation Sector II (NI-L1052)	2012	31.9		12.8%
Support to Transportation Sector III (NI-L1071)	2013	91.5		0.0%
Transportation Infrastructure Rehabilitation Program (JA-L1016)	2008	50.0	JA-T1050	80%

4.32 OVE's analysis focused on project design; since this is a young portfolio, it would be too early to analyze its execution and results.[106] The analysis sought to establish whether (i) the diagnostic adequately identified the problem relating to infrastructure vulnerability and transport services in the project's intervention area, (ii) the proposed intervention addressed the question in a coherent way, and (iii) the projects had efficient monitoring and reporting mechanisms to provide accountability for their results.

4.33 The *Flood Mitigation and Infrastructure Program for Belize City* (BL-L1013) sought to reduce the city's vulnerability to flooding events through the rehabilitation, improvement, and protection of the city's drainage and urban road networks. The project was highly relevant, tackling a priority problem for the city, which periodically experiences floods caused by severe weather systems and storm surges.[107] However, even though the project's main expected outcome is "reduction of flood levels and duration," it is not clear how the CC dimension was incorporated into project design; there is no evidence in the project documentation that technical specifications for civil works were reviewed or adjusted to consider the potential impacts of future weather patterns, as opposed to following standard specifications for the type of work involved. The project lacks an appropriate monitoring and evaluation system with indicator baselines and targets, but there is parallel TC funding (BL-T1050) to develop one.

4.34 The El Salvador project (*Rural connectivity program for the northern and eastern zones*, ES-L1061) was designed to improve rural road conditions in the eastern and northern zones and to reduce vulnerability to CC. The diagnostic used information generated by the National Territorial Studies Service (Servicio Nacional de Estudios Territoriales) to discuss how the effects of climate change have left the road network

106 With the exception of the project in Jamaica (JA-L1016).

107 One of the project's antecedents is the Emergency Road Rehabilitation Program (*Programa de Emergencia para la Rehabilitación de Carreteras*), approved in response to the floods caused by Tropical Depression Nº 16 (BL-L1010).

in poor condition.[108] The project's approach to CC adaptation is limited to institutional strengthening through a US$400,000 component of a US$15 million loan. The project's documentation is not clear on the mechanism through which the institutional strengthening will help reduce the road infrastructure's vulnerability to climate change. The project also lacks a system for efficient monitoring and reporting of results.

4.35 The Bank's intervention in Nicaragua includes three operations to support the transport sector by improving road transport efficiency. The program as a whole is relevant in that it addresses deficiencies in institutional capacity and in the condition of the road network. The program documents the poor condition of the country's road infrastructure and its vulnerability to recurring natural phenomena; however, the diagnostic lacks sufficient data to measure the problem in terms of traffic disruptions in the areas of intervention and to establish a baseline against which to measure results. The objectives of the two latest operations (NI-L1052 and NI-L1071) include reducing the road network's vulnerability to CC, along with more traditional goals such as reducing travel times and costs. There is a noticeable effort to link the design of the adaptation-related components to forecasts of future extreme weather events and not only to historical information about rising sea levels and tropical storm intensity and frequency.[109]

4.36 This program contains a logical intervention sequence:[110] the first operation includes a small component (US$400,000) to map hot spots in the network; the second finances feasibility studies of the Chinandega-Guasaule road;[111] and the third and final operation finances (US$3.3 million) the works for the critical road access points on the border with Honduras.

4.37 The monitoring mechanisms of three operations that make up the Nicaraguan program vary in quality; none of them is set to measure outcomes of reducing road network vulnerability. The first project includes a results indicator to measure traffic disruptions caused by *force majeure* lasting for more than 24 hours, but this indicator does not reappear in subsequent operations. The others include indicators for products such as works designed with respect to vulnerability to CC, or works carried out on critical points, but they lack baselines or sufficient specificity. Given that this is a program that takes an innovative approach in an area in which the Bank has little experience, it is particularly important to closely monitor it for future operations.

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108 According to the loan document, the National Territorial Studies Service documents changes in rainfall patterns in terms of intensity and high concentrations in a short time.

109 Environmental and Social Management Report (Informe de Gestión Ambiental y Social) on the second loan. The report describes the problems relating to natural disasters in Nicaragua based on historic trends and future projections, such as those of the IPCC.

110 The sequence involves (i) identification of risks and vulnerable zones; (ii) infrastructure strengthening and technical specifications; and (iii) construction/rehabilitation of alternative routes.

111 This is a highly important road in terms of international trade, and it is cut each winter by flooding in one particular 28-km section.

4.38 The Bank's intervention in Jamaica (JA-L1016) was relevant and well integrated with the rest of the Bank's work in the sector. The project followed an emergency operation (*Emergency Assistance in Response to Flood Damage*) that was approved in 2008 to restore services and basic mobility following the damage caused in the hurricane season of 2007. It included the rehabilitation of selected sections of the national road network, and involved substantial repairs that could not be covered under the emergency assistance project because rebuilding the same infrastructure in the same way would result in similar damage in future storms. Project implementation is on track, and the project is expected to be completed without major delays.

4.39 The project was to incorporate measures to mitigate the impacts of CC, but it is unclear how it would do so as it does not specify what conditions, requirements, or specifications would be part of the works to allow for a rehabilitation that is different from standard designs. The project lacks indicators to monitor and report on the reduction of damages to infrastructure and transportation services that would result from the program.

4.40 In sum, while the explicit adaptation portfolio is highly relevant, it is still young and has a ways to go to develop robust indicators on CC resilience impacts and to apply them consistently across projects. Given the challenges of downscaling CC predictions and the uncertainty of forecasts at the local level, setting targets and monitoring progress may continue to be an imprecise process. However, it is still important that the Bank continue to forge ahead in this area. In addition, road maintenance, a component of many of the bank transport projects reviewed, is an important and cost-effective strategy (see Kopp et al., 2013) for improving resilience that should continue to be fostered.

V. CONCLUSIONS AND SUGGESTIONS

5.1 Effectively and efficiently mainstreaming both CC mitigation and adaptation strategies is essential to ensuring a sustainable economic development path that generates not only global but important local benefits to LAC populations. Such benefits include improvements in air quality, traffic safety, and increased mobility and access to goods and services for all income groups, but particularly for lower-income groups who are more dependent on public transport, walking, and biking. Although integrating CC mitigation strategies into projects has local costs, it also brings significant co-benefits that can make the projects economically viable for countries facing key trade-offs in the allocation of scarce financial resources.

5.2 In the Climate Change Strategy of 2011, the Bank recognized the importance of promoting sustainable low-carbon transportation solutions for passengers and freight in both urban and rural settings. The transport sector, which had already adopted sustainable transport as one of its three lines of action, incorporated this vision into its key strategic documents and the most recent sector framework (though only for urban transport in the framework). However, results at the portfolio level have been limited for loans—since 2008, only about 33% of the transport lending portfolio has been explicitly or implicitly related to CC—but more successful for TCs.

5.3 At the project level, the evaluation found the following:

- Weaknesses in the analytic basis of CC-related transport projects (with explicit and implicit CC objectives), both in the completeness of their diagnostics and in the soundness of their results matrices and monitoring and reporting mechanisms.

- Important emission reductions in the four urban mass transportation projects for which emissions benefits were estimated (two metro lines and two BRTs). In the BRT projects, restructuring of routes resulted in fewer bus kilometers traveled to serve the same number of trips. However, several issues—including slow construction, difficulty in decommissioning obsolete polluting buses, and financial difficulties of the bus operators—have affected the capacity of the systems to fully meet mobility needs, and, thus, the net reductions in emissions resulting from the system.

- The roads projects for which emissions were estimated (São Paulo beltway Oeste and Norte, and two interurban roads) showed significant short-term reductions in emissions relative to the business-as-usual scenario. When vehicle congestion levels are high, projects that increase the road network's capacity, such as the São Paulo metropolitan beltway, can improve driving conditions and shorten travel distances for a significant number of private vehicles and freight carriers. However, the medium- and long-term effects of these projects are not so clear. Planners tend to underestimate the induced traffic from these improvements, and to overestimate how long this additional capacity will be able to maintain service levels.

- Few projects with explicit adaptation objectives have been approved since 2008; the Bank's action in the field of adaptation to CC is still in its infancy and therefore difficult to assess. There are data limitations in the diagnostics and in the definition of the proposed interventions; in addition, when project monitoring systems included adaptation indicators, they usually lacked specificity and baselines.

5.4 For the Bank to fully implement its vision in the transport sector, OVE makes the following suggestions:

- Develop a policy guidelines with respect to CO_2 and other GHG emissions from transport projects with the following requirements: (i) for all projects, estimate emissions ex ante against a business-as-usual scenario for the 20-year life of the project, using an improved methodology that takes into account all stages of project design and implementation; and (ii) for projects with significant emissions, consider lower-carbon alternatives or incorporate mitigation and/or compensation measures into project design. This policy should consider highlighting the importance of taking a systemwide approach in analyzing the potential impacts of projects on GHG emissions as well as tracking and monitoring progress on emissions reductions during and after project execution.[112]

- Strengthen the analysis underlying CC-related projects by including sufficient data and information to clearly identify the mitigation or adaptation problems to be addressed, establishing a baseline to track progress, and including systematic monitoring and reporting mechanisms to measure progress and results.

- Strengthen the design of CC-related projects by systematically incorporating policy dialogue with client governments around potential complementary or "transport demand-side" measures or "avoid" strategies to support infrastructure solutions.[113]

- Strengthen Bank action on adaptation by adopting an intervention model that describes the continuum of possible interventions according to the "risk assessment – infrastructure protection/strengthening – alternate creation" framework, and develop a set of core indicators for proper diagnostics and efficient monitoring and reporting of results.

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112 See WRI's GHG Mitigation Standards: http://www.ghgprotocol.org/files/ghgp/GHG%20Protocol%20Mitigation%20Goals%20Standard%20-%20Draft%20for%20Review%20Group%20-%20November%202012.pdf for potential guidelines on measuring emissions.

113 Such "avoid" or demand-side measures include promoting transit-oriented development, travel demand management, and transport pricing.

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ANNEXES

ANNEX I: ANALYSIS OF THE TCS OF THE TRANSPORT SECTOR, 2004-2013

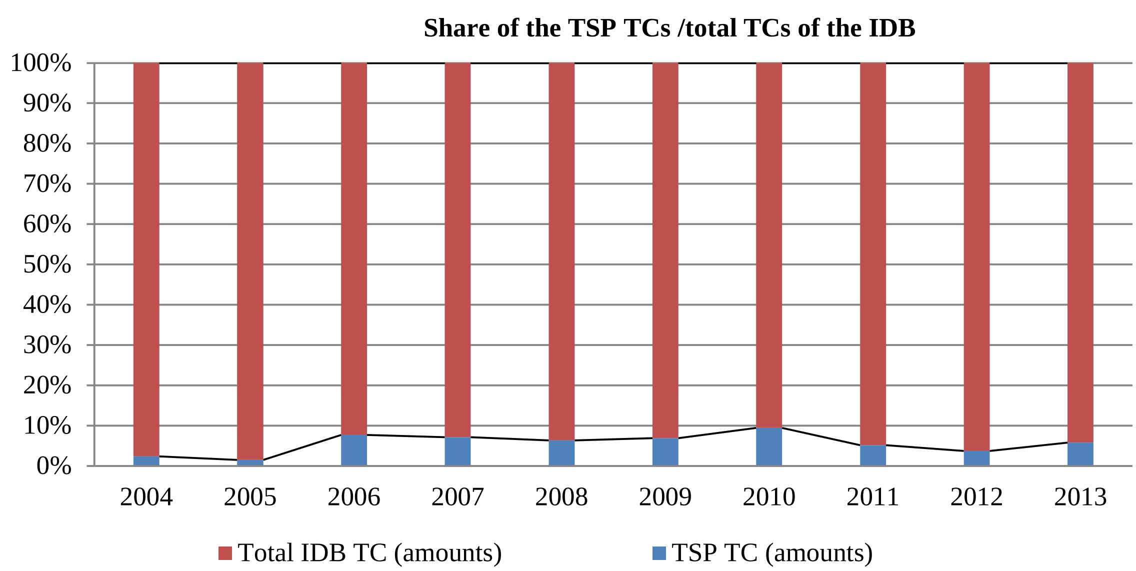
Over the last ten years (2004-2013), the TCs approved in the Transport Sector (TSP) focused more and more on projects related to CC. After 2008 there was a significant increase in the number of approved projects and approved amounts. This is particularly due to greater investment in logistics projects and to important and sustained investment in urban mobility projects, especially mass transit.

However, even if the CC related TC portfolio diversified over time and included more multi-modal projects, the CC related TCs are still concentrated in certain regions (CSC and CAN), specifically in three countries (Brazil, Colombia and Argentina). Especially, important projects for CC adaptation or mitigation, such as non-motorized transport or urban planning, remained insufficiently financed throughout the region.

1. Analysis of the TC portfolio of the Transport Sector

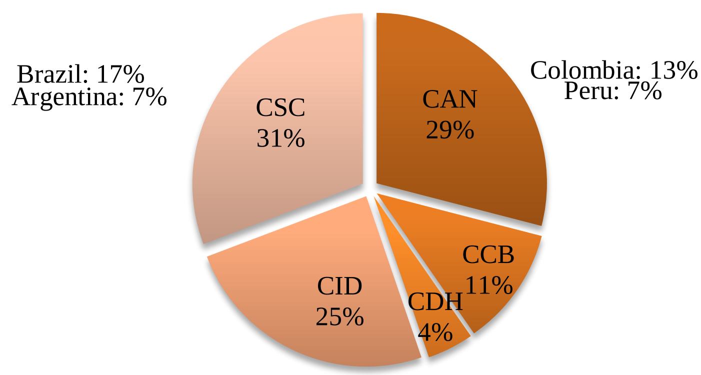
Between 2004 and 2013, the 146 approved TCs for the TSP, amounted US$103 million, 6.4% of the total approved TCs (US$1.63 billion). This amount remained stable, below about 10% of the total amount of approved TCs.

With the exception of the regional TCs, about two-thirds (63%) of the TSP TCs were approved in Southern Cone countries (CSC) and the Andean region (CAN); which also reflected in the approved amounts (60% of the total amounts of TSP TCs).



At country level (without the regional TC), there is a great concentration of TSP TCs in Brazil, Colombia and Peru, which accounts for about 45% of the approved amounts. In addition, Brazil, Colombia and Argentina gather more than one third (37%) of the approved TSP TCs, as well as the approved amounts.

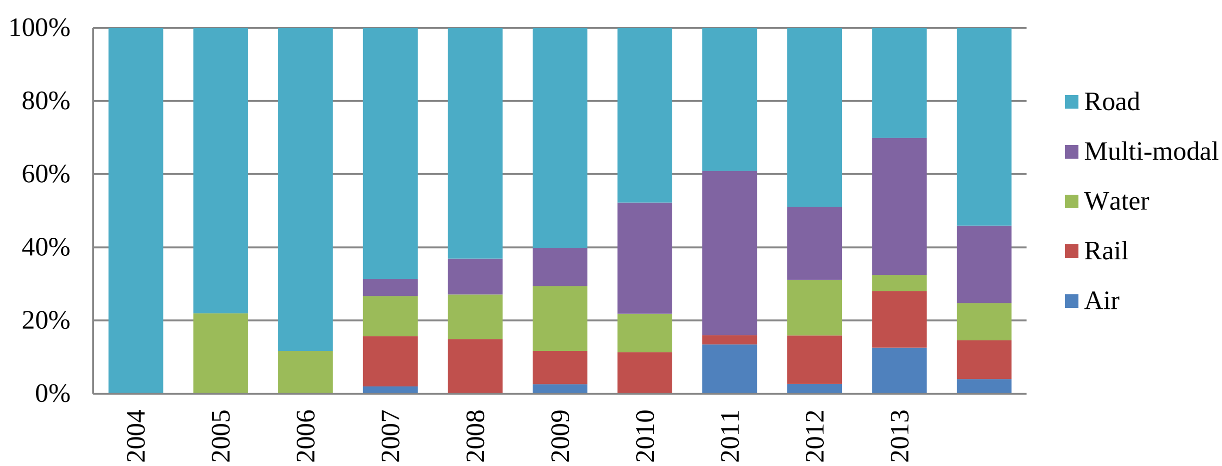
Analysis of the amounts of TCs for TSP, approved by region and by country, between 2004 and 2013



This period is characterized by increased diversification in the type of approved TSP TCs. Between 2000 and 2009, the majority of approved projects were road projects.

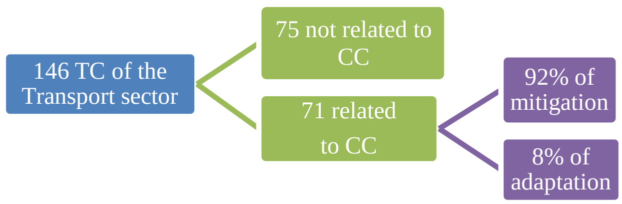
After 2010, more than half of the TSP TCs was related to air, rail, water and multi-modal transportation; the approved amounts for road transport decreased from 72% (between 2004-2008) to 45% (2009-2013) of the total amounts. In the meantime, multi-modal projects, which favor modal integration and can permit an increase in transport efficiency, increased from 5% to 28% of the total amounts.

Amounts of the approved TCs, by type of transportation, 2004-2013



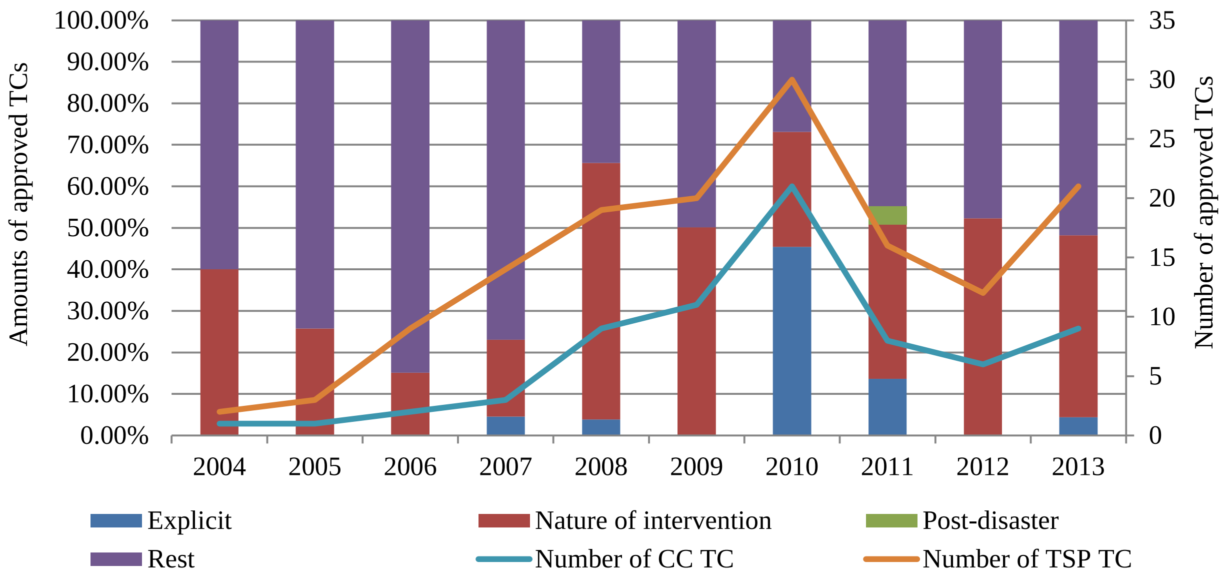
2. TC of the Transport Sector and their relation to climate change

Between 2004 and 2013, nearly half (71) of the 146 approved TSP TCs were considered to be related to CC[114], whether they were CC adaptation projects (7/71) or mitigation projects[115] (67/71).



This period is characterized by an increase in the number of TSP TCs that are related to CC; from representing 35% (between 2004 and 2008) to 54% (between 2009 and 2013). Similarly, the CC TCs amounts approved increased from 34% to 57% for TSP TC, over the same periods. However, only 27% of the CC TC possessed an *explicit* objective in relation to CC.

Evolution in the numbers and amounts of approved TCs, 2004-2013



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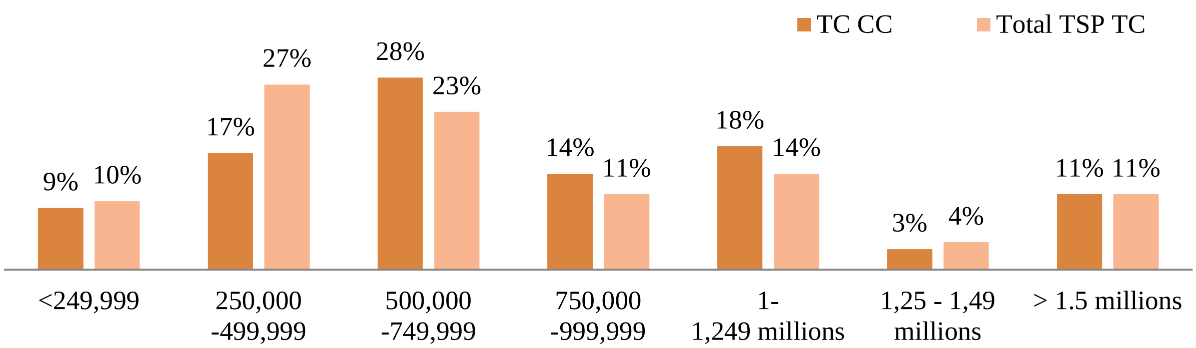
114 To define the projects that are related to CC, the following criteria were considered:
- Projects which objective mention: (i) emission reduction or (ii) increase the resilience of the transportation infrastructure
- Projects in which one of their components mention: (i) emission reduction or (ii) increase the resilience of the transportation infrastructure
- Projects that do not mention a CC objective but for which, given the *nature* of their intervention, a positive impact is expected (ex: BRT, mass transit urban projects, logistics)
- Projects that respond to damage in the transportation infrastructure caused by disasters provoked by climatic events

115 The group of Mitigation TCs includes four TCs that are both of mitigation and adaptation; for the purpose of the evaluation they are included in the “mitigation” category given they are urban mobility projects that possess “mitigation” actions as their main component.

The distribution of amounts is similar between the CC TCs and the overall TSP TCs. However, the average amount for each CC TC (US$760,000) is 7% more than the average amount for each TSP TC in general (US$710,000). In addition, the median amount of the CC TCs was US$700,000 while it was US$600,000 for each TC of TSP. The origin of the funds is similar between the two categories of TCs, with 42% of the CC TCs and 46% of the TSP TCs financed through Special Programs.

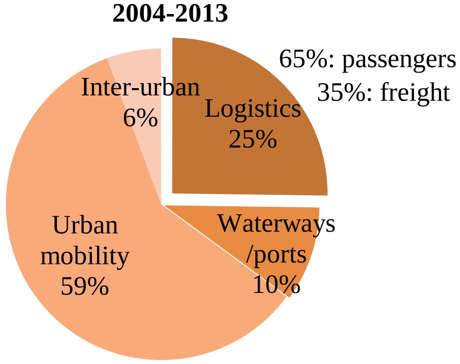
Analysis of amounts of CC TCs, 2004-2013



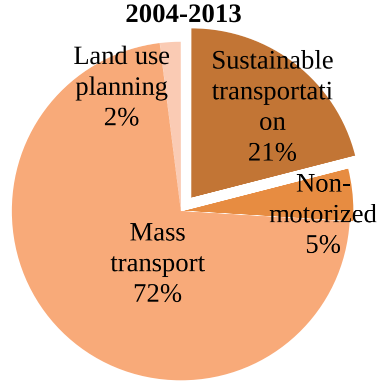
3. Characterization of the climate change related transport sector TC

The majority of CC related TSP TCs were mitigation projects (92%), whether they possessed an *explicit* CC objective or categorized as mitigation projects given the *nature of their intervention*. More than 60% of those mitigation projects are related to passenger transportation and especially to urban mobility, which represents more than half of the total number (60%) and total amounts approved for the mitigation TCs. The urban mobility projects are mainly related to mass transport, such as buses, BRT or metro systems. Very little was financed for non-motorized transport or land use planning, even though these are two essential areas of intervention regarding the improvement of environmental sustainability of the transport sector. However, these areas of intervention were included within *sustainable transport* projects that combines mass transit, non-motorized transport and land use planning, and that consist mostly on the development of mobility plans.

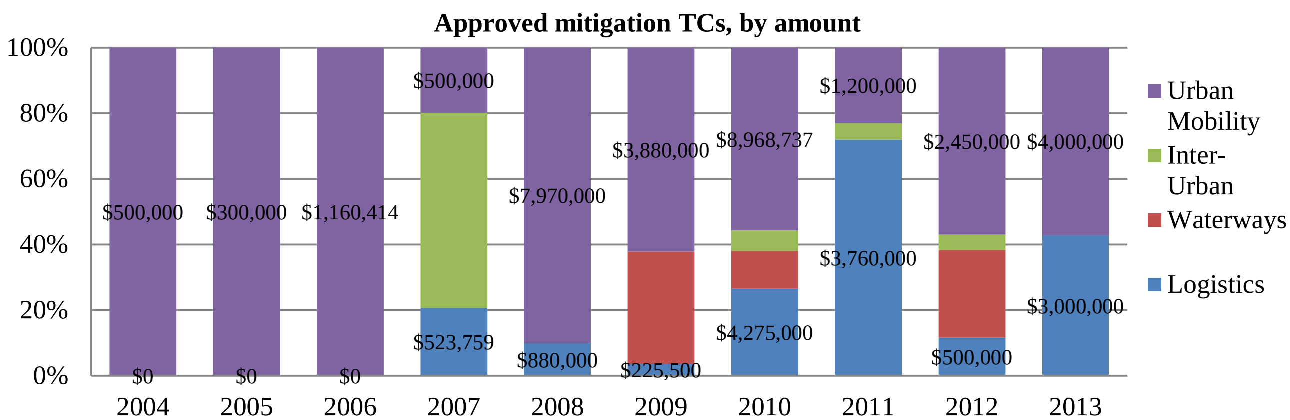
Mitigation TCs approved, by amount, 2004-2013



Urban mobility TCs approved, by amount, 2004-2013

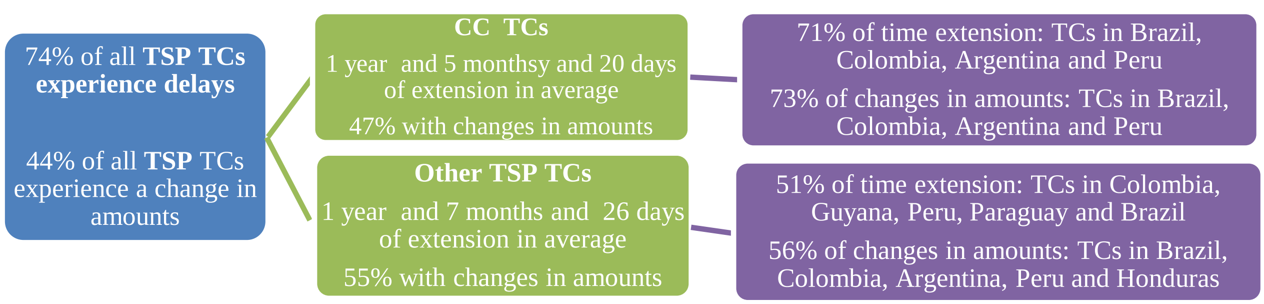


Between 2004 and 2013 the approved mitigation TCs got more diversified, with more logistics projects, which amounts increased from 6% to 31% of the total amounts for the mitigation TCs approved between the periods 2004-2008 and 2009-2013. Conversely, during those periods, the share of projects for passenger transportation considerably decreased, especially those of urban mobility, from representing 81% to 49% of the total. However, the total amounts of urban mobility and logistics projects considerably increased.



Only four *adaptation* TCs were approved, for the rehabilitation or strengthening of road infrastructure that are exposed to natural disasters (three TCs) and for port infrastructure (one TC); they were all approved after 2009, mainly in the Central America region (CID).

The CC TCs have similar extension schemes than other TSP TCs for the project period and amounts; these extensions mostly occur in countries that gather the majority of the approved number of TCs and amounts.

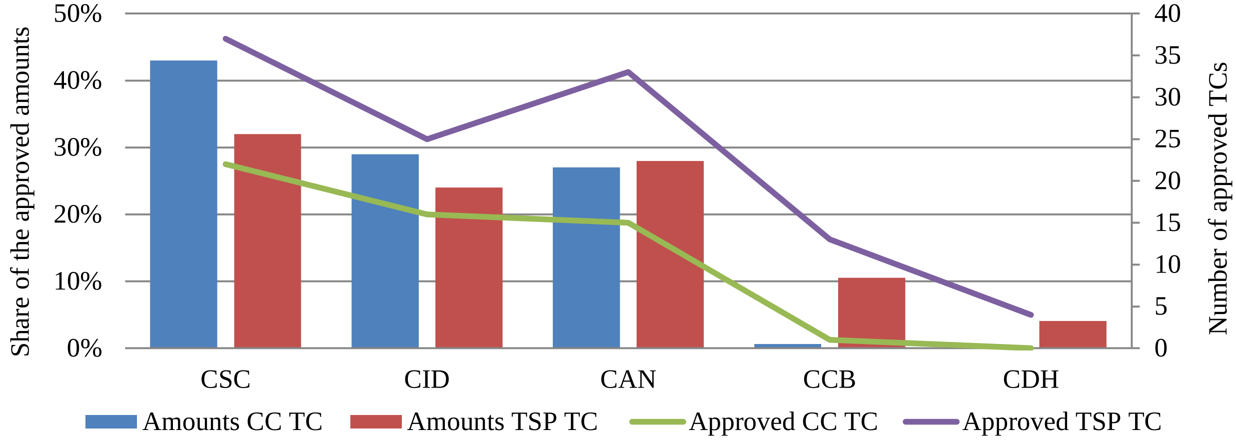


Nearly the totality (98.5%) of the changes in amounts for both TC categories implied a reduction in the amounts. However, only 20% of the CC TCs (and 14% of the TSP TCs), experienced a reduction of more than 50% in their original approved amount, which generally implied the cancellation of one or more components of the project.

4. Localization of the CC TC

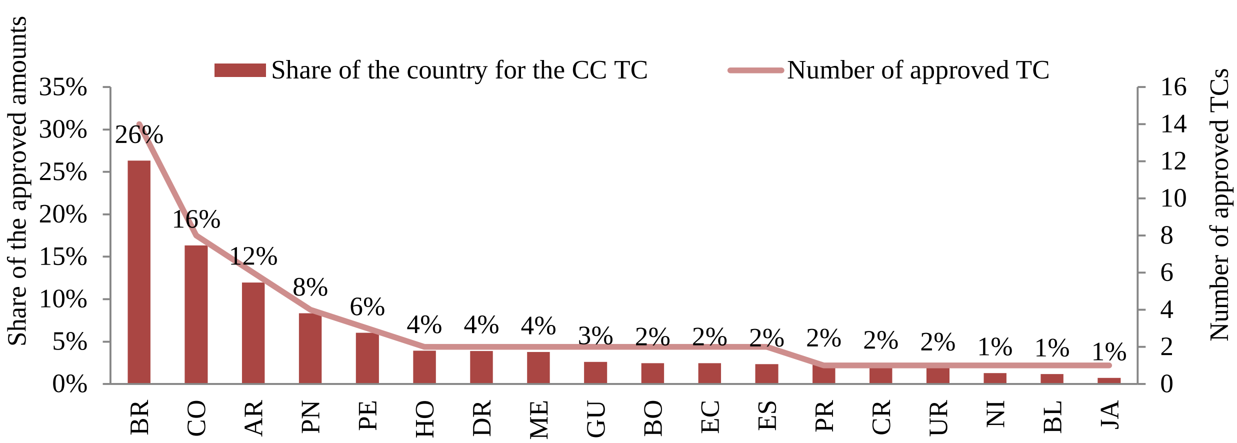
The analysis of the localization of the non-regional CC TCs indicates an important concentration of those TCs in CSC, CID and CAN, which is similar to the concentration of TSP TCs in general. Regarding approved amounts for CC TCs, there is a similar concentration in the CSC countries (43%), CID (29%) and CAN (27%) regions. In contrast, the amounts approved for all TSP TCs are more equally distributed among those regions. Finally, the Caribbean countries receive the least, in terms of approved TCs and amounts, for CC (1%) while they receive about 15% for projects of the TSP sector in general.

Comparison of the numbers and amounts of approved CC TCs and TSP TCs, 2004-2013



At the country level, the concentration of CC TCs is even more important. Sixty nine percent of the approved amounts are concentrated among Five countries (Brazil, Colombia, Argentina, Panama and Peru) and 64% of the number of those TC. Especially, only Brazil and Colombia concentrate 42% of the approved amounts.

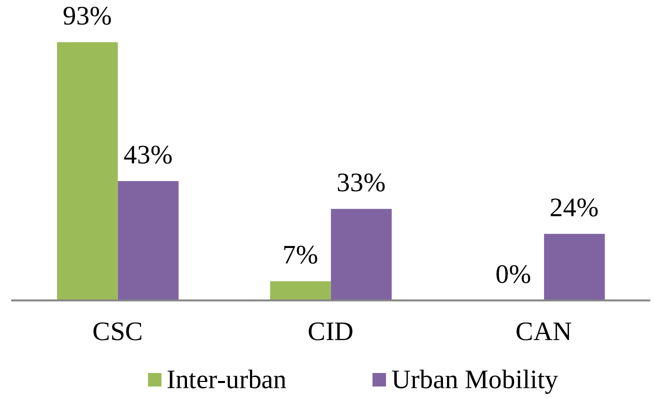
Amounts of CC TCs approved and number of approved CC TCs by country, 2004-2013



Nearly half (47%) of the urban mobility projects and of inter-urban passenger projects, are developed in CSCs. In terms of amounts, this concentration is even more important, with 65% of the amounts for urban mobility projects approved in four countries (Brazil, Argentina, Colombia and Panama).

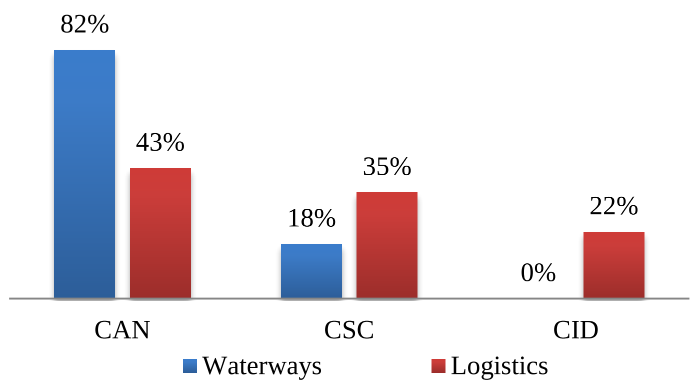
Conversely, the Caribbean (CCN) does not include any urban mobility or inter-urban transport TC.

CC TCs for passenger transportation approved by amount, 2004-2013



Seventy seven percent of the approved TCs for freight were focused in logistics ways and 23% in maritime transport or for waterways. The majority of funds for the CAN were concentrated in maritime transport and nearly half of the funds for logistics ways. At country level, Colombia, Brazil, Peru and Mexico gathered 86% of the amounts of the approved TCs for freight transport. Meanwhile none of these type of projects were included in the Caribbean..

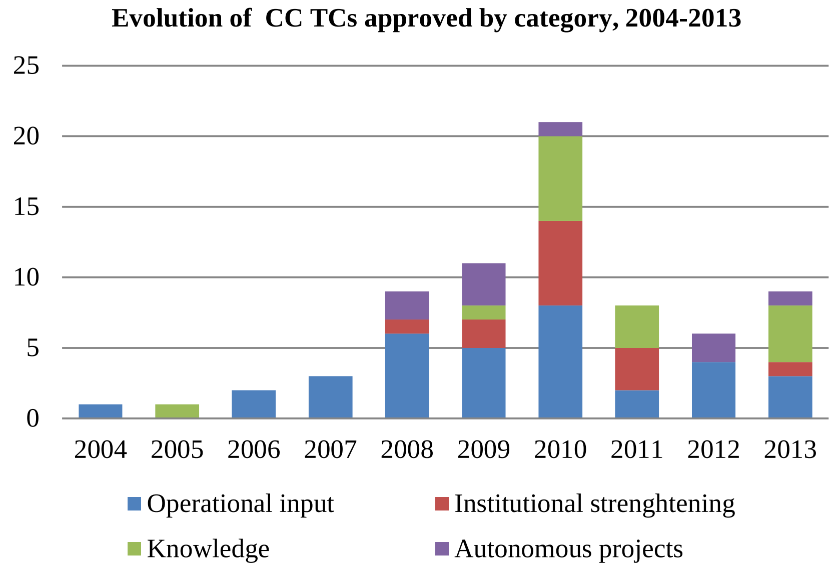
CC TC for freight, approved by amount, 2004-2013

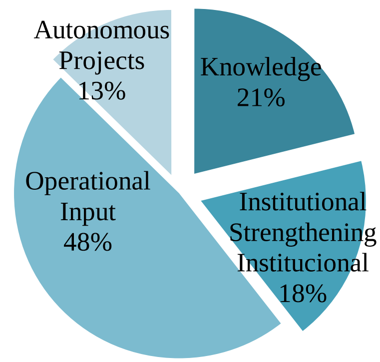


In addition, 16 regional CC TCs were approved since 2008. They account for about 22% of the CC TCs, a similar proportion than for the general TSP portfolio during the 2004-2013 period. If 22% of those TCs cover the entire region, there is also an important concentration of those regional TCs in CID (26%), CAN (Colombia and Peru) and CSC (Brazil and Argentina). Eighty one percent of those regional TCs are implemented by the Bank and, in 70% of the cases, those regional TCs are focused on the dissemination of knowledge related to CC through the development of regional observatories for freight or through support to sustainable transportation plans.

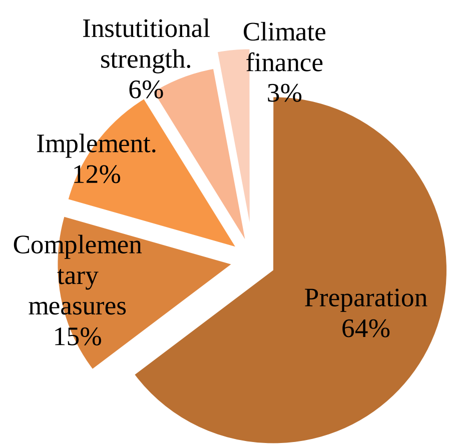
5. Categorization of the CC TC

The CC TCs were classified into four categories, according to their principal objectives:





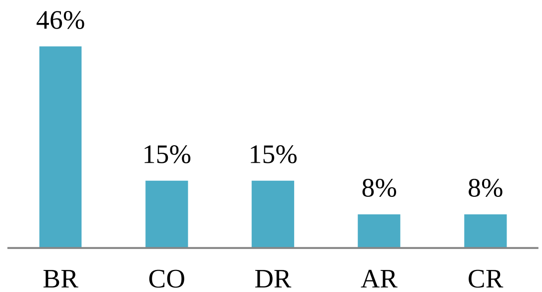
The most important CC TCs category is related to *Operational Input*, with TC related to Bank's loan operations. Half of those TCs are implemented in countries in which the majority of transport operations related to CC (Brazil, Colombia and Argentina) are concentrated. They are mostly focused on passenger transportation and urban mobility (73%). The majority of those TCs include the development of diverse type of feasibility studies to define the technical characteristics and scope of transportation projects. This category also supports the preparation of adaptation projects. The complementary measures provided by these TCs support the development of strategies, the revision of legal, institutional and financial frameworks, the planning of land use management of transportation or monitoring systems.



To foster knowledge about CC, *Knowledge* category TCs are mostly implemented at regional level (73%) or in the CID (20%), through the creation of regional observatories, the development of information systems or common indicators. They also encourage the exchange of experiences through forums, especially related to urban mobility, that can support the preparation of transportation plans.

In the case of TCs related to the *Institutional Strengthening* of public and private sectors, the projects supported inter-sectorial and inter-institutional dialogue, the revision of studies, policies, legal frameworks and mobility strategies and technical assistance related to management, the negotiation of concession contracts in the case of public-private partnerships and technological tools that ease transportation management. In addition, they included support to the design of NAM plans. This category mostly focused on urban mobility projects (54% of the TCs in this category) and the projects were developed only in five countries (mostly in Brazil).

Location of CC TCs for the Institutional Strengtening category, 2004-2013



The last TC category provided supported the development of Autonomous Projects and Pilot Programs, mostly through regional TCs (56% of the TCs in this category). They mostly focused on support to feasibility studies and on the designs needed for the construction of infrastructure for urban transport projects, such as the development of a pilot project of hybrid buses or the improvement of transport infrastructure for freight.

ANNEX II: METHOD FOR ESTIMATING GHG EMISSIONS FROM TRANSPORT PROJECTS

A. Introduction

Most projects that seek to improve the efficiency of transport systems might, explicitly or implicitly, have short-term positive effects in reducing GHG emissions from transport. These reductions can be estimated using different methodologies and tools. Long-term impacts are more difficult to estimate, particularly when considering the effects of economic growth on motorization rates, and induced traffic when the road network is upgraded. Another element of complexity, in the case of transport projects, is that GHG emissions depend on how the transport network functions, and multiple projects and policies can happen simultaneously.

It is possible to create transport models that take into account all these complexities and caveats, but they can be expensive and the required information might not be available for every project. Despite this, an approximation can be made to the direction and dimension of the effect a project might have on GHG emissions, and provide an estimate of the change in GHG emissions due to a specific project. It is important to note that these effects consider the project as a whole, and cannot differentiate the proportion of these reductions that correspond to IDBs technical or financial contribution.

B. Project Typology

With the goal of developing specific analysis of transport projects linked to CC mitigation, different project typologies are proposed. Table 1 shows the main categories and how they relate to the mitigation strategies of avoid, shift, and improve. Some project types have more clear effects in specific strategies, while others it is more difficult to assess.

Table 1 – Transport Project Typology and its Relation to Climate Change

Territory	Typology	Impacts Related to Mitigation
Urban	Mass transit (metro, BRT)	- Reduce car usage (S) - Reduce usage of older buses (S) - New bus technology (I)
	Urban mobility planning	- Reduce car usage (A) - Reduce usage of older buses (S) - New routing technologies (I)
	Urban highways	- Increase travel speeds (I)
	Non-motorized transport	- Reduce car usage (A) (S)
	Freight corridors	- Increase operational speeds (S) - Reduce congestion (I)
	Urban logistics	- Reduce usage of bigger trucks (S) - Reduce congestion on city streets (I)
Inter-Urban	Freight corridors	- Reduce congestion on mixed lanes (I) - Increase operational speeds (I)
	Road maintenance	- Improve operation conditions (I)
	Rural roads	- Improve operation conditions (I)
	Alternative roads	- Increase operational speeds (I)

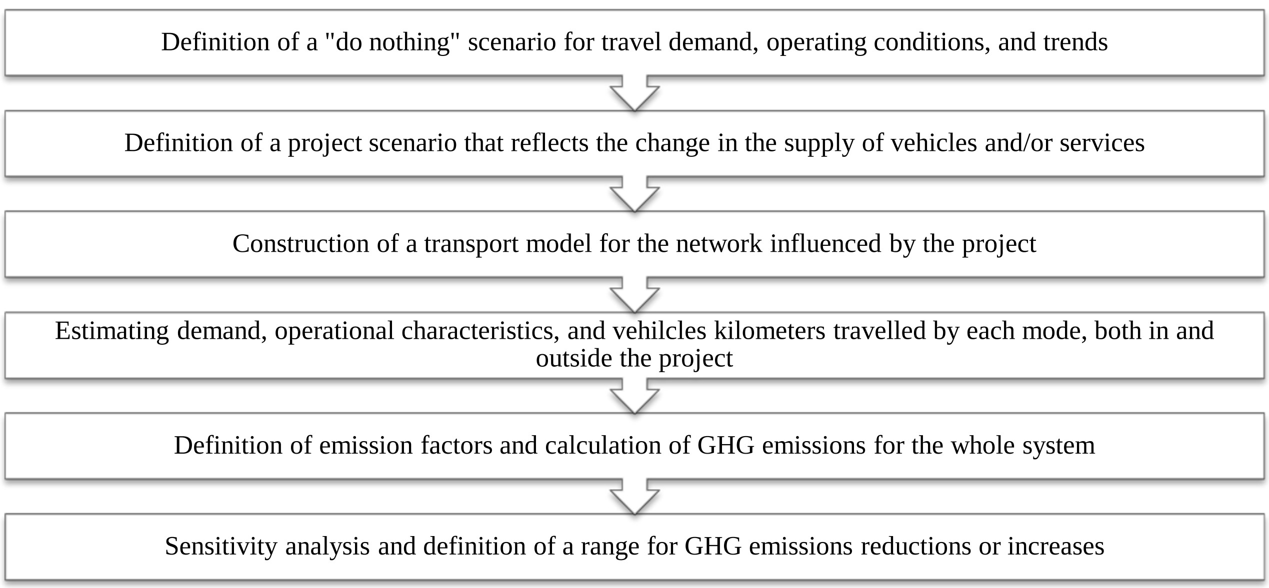
Mitigation: (I) Improve, (S) Shift, (A) Avoid

C. Methodology for Estimating Change in GHG Emissions

GHG emissions are directly related to energy consumption, particularly from fossil fuel combustion. A project that reduces fuel consumption then implies a corresponding reduction in GHG emissions. To determine the impact of a project it is necessary to compare not the baseline with the current emissions, but instead compare the situation with project with an alternative situation without the project, also called a do nothing scenario.

An integral evaluation for any transport project should follow a procedure similar to the one represented in Figure 1. This procedure requires the use of complex transport models, and extensive information about the socioeconomic characteristics of the area influenced by the project, travel patterns, and the transport network, which in most cases is not available.

Figure 1 – GHG Emissions Estimation Methodology for Transport Projects



The exercise requires not only a baseline for the transport project, but for the transport network of which the project is part of. This is necessary because the impacts, both positive and negative, will accrue to the system as a whole. For example, a metro line would, in theory, eliminate traditional bus lines, thus reducing congestion and in the short run allowing for a faster moving speed for the remaining vehicles. Surrounding corridors will benefit, and even improve operational efficiency for remaining traditional bus routes.

In the case of urban highways, a transport model allows to determine what portion of current traffic will use the new infrastructure, and from which roads they will be transferring from. The assumptions behind the transport model would also determine the operating conditions of the network once new infrastructure is built. In the long run, induced traffic due to an increase in road supply should also be taken into account, considering that a less congested infrastructure means less cost for using automobiles.

Another critical aspect is the definition of emission factors for each type of vehicle. The factors depend on the type, age, fuel, and operation conditions of each vehicle. Tools like the HDM IV allow more accurate calculations that consider changes in speed when estimating fuel consumption, but it is also important to consider changes in driving behaviors and cycles, which can explain even more changes in fuel consumption. The analysis requires so many different parameters and multiple levels of uncertainty that providing different scenarios illustrate the sensitivity of the estimation to changes in the principal components.

D. Estimating CO2 Emissions for IDB Projects

When enough information is not available to develop estimates for the operating characteristics of the transport network, or in the cases where transport models are not available, the estimations follow a simplified procedure that, although less precise, still determines if there is potential for reducing emissions and its order of magnitude. Figure 2 shows the steps to be followed for IDB projects.

Figure 2 – Simplified Methodology for Estimating Change in GHG Emissions for Transport Projects