THE INFRASTRUCTURE GAP IN LATIN AMERICA AND THE CARIBBEAN

Investment needed through 2030 to meet the Sustainable Development Goals

Juan Pablo Brichetti
Leonardo Mastronardi
María Eugenia Rivas Amiassorho
Tomás Serebrisky
Ben Solís

IDB

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
The infrastructure gap in Latin America and the Caribbean: investment needed through 2030 to meet the sustainable development goals / Juan Pablo Brichetti, Leonardo Mastronardi, María Eugenia Rivas Amiassorho, Tomás Serebrisky, Ben Solís.
p. cm. — (IDB Monograph ; 962)
Includes bibliographic references.
1. Infrastructure (Economics)-Latin America-Finance. 2. Infrastructure (Economics)-Caribbean Area-Finance. 3. Infrastructure (Economics)-Environmental aspects-Latin America. 4. Infrastructure (Economics)-Environmental aspects-Caribbean Area. 5. Sustainable development-Latin America. 6. Sustainable development-Caribbean Area. I. Brichetti, Juan Pablo. II. Mastronardi, Leonardo. III. Rivas, María Eugenia. IV. Serebrisky, Tomás. V. Solís, Ben. VI. Inter-American Development Bank. Infrastructure and Energy Sector. VII. Serie.
IDB-MG-962

JEL codes: N76, O18, H54, Q01, L92, L93, L94, L95, L96

Key words: infrastructure gap, Latin America, Caribbean, SDGs, investments, water, sanitation, electricity, transport, telecommunications

Design: Cleiman https://cleiman.com/

http://www.iadb.org

Contents

ANNEX

METHODOLOGY FOR THE ESTIMATION OF THE INFRASTRUCTURE GAP AND INVESTMENT NEEDED THROUGH 2030 TO MEET THE SUSTAINABLE DEVELOPMENT GOALS IN LATIN AMERICA AND THE CARIBBEAN XVI

Acknowledgments

The authors wish to thank our Inter-American Development Bank colleagues and external reviewers, who contributed valuable observations and comments as this document took shape.

Among our many colleagues offering invaluable technical expertise, we are especially grateful to José Agustín Aguerre, Lenin Balza, Camilo De Los Ríos, José Luis Irigoyen, and María Cecilia Ramírez (INE/INE); Enrique Chueca Montuenga, Michelle Hallack, David López Soto, Alexandre Mejdalani, and Pauline Ravillard (INE/ENE); Felipe Bedoya, Agustina Calatayud, Francisca Giraldez, Carlos Mojica, and Santiago Sánchez González (INE/TSP); María Julia Bocco, Darcia Datshkovsky, María Eugenia de la Peña, Analía Gómez Vidal, Fabiana Machado, Kleber Machado, Henry Moreno, Alejandra Perroni, and Manuela Velásquez (INE/WSA); Antonio García Zaballos, Enrique Iglesias, and Pau Puig (CFM/IFD); Adrien Vogt-Schilb (CCS/CSD), Ancor Suárez Alemán, and Gastón Astesiano (VPC); and José Luis Bonifaz (external reviewer). Steven B. Kennedy edited the text and made valuable language suggestions to the sections of this document.

The opinions in this publication are exclusively the authors' and do not reflect in any way the opinion of the Inter-American Development Bank nor that of its executive directors. Any errors and omissions are exclusively the authors' responsibility.

We dedicate this work to the memory of Leonardo Mastronardi. Excellent professional and even better person. We will always remember you as attentive, warm and an excellent friend. We will miss you Leo.

Juan Pablo Brichetti - María Eugenia Rivas - Tomás Serebrisky - Ben Solís

EXECUTIVE SUMMARY

Despite progress in Latin America and the Caribbean over the past two decades, the region's many challenges—economic, social, and environmental— have been laid bare by the COVID-19 pandemic. Worldwide, the path toward sustainable development is fraught with barriers. Attaining the Sustainable Development Goals (SDGs) requires societies and policymakers to decide how to promote growth, reduce inequality, and protect the environment. While it is difficult to establish goals in this context, it is also unavoidable. A secure and more inclusive future depends on it. In this sense, **the SDGs, established in 2015 by the UN serve to guide countries along the path to development, while balancing the various and sometimes conflicting goals**.

The Inter-American Development Bank (IDB), in its 2025 Vision, laid down some guiding principles and priorities in line with the SDGs. These seek to promote sustainable and inclusive economic growth. Guaranteeing access to infrastructure capable of providing sustainable and quality services to the region's households and firms is a necessary condition for building a dynamic and digitalized economy which, in turn, can create opportunities for innovation and growth –especially for small and medium firms– and foster the inclusion of vulnerable and low-income populations. In addition, high-quality infrastructure permits the region's integration in continental and global value chains.

OUR AIM

This report aims to **estimate the amount that Latin America and the Caribbean should invest in infrastructure by 2030 if the region is to meet the Sustainable Development Goals.** While the SDGs are not binding commitments, they are an internationally recognized reference: goals that all countries are meant to achieve by 2030.

We should emphasize that the **investments estimated in this report do not imply complete fulfillment of the SDGs related to the provision of infrastructure services**. The estimates have their limitations, which we try to explain throughout the report. In addition, **the SDGs are comprehensive. The goals extend to affordability, resilience, and sustainability issues**, which will require programs to go beyond infrastructure investments to embrace, for example, targeted subsidies, demand management, and infrastructure design able to withstand the disaster risks related to climate change.

The estimates provided in this report should therefore be seen as a lower bound. Complementary estimates can be made to determine resources that will need to go toward more sustainable infrastructure services. These investments include a greater and faster increase in renewables energies within the regional energy mix, electricity transmission lines that augment regional integration, flood control works, and resilient water and sanitation networks. Also, in the climate change context, cities will require green infrastructure that ensure water quality and quantity.

OUR METHODOLOGY

This report presents a tool for calculating investment needs in a modular and consistent way. A first step in our methodology is to identify SDG indicators tied to public service infrastructure, given that sometimes SDG do not include specific quantitative targets. Using our methodology, users will be able to replicate the calculations with different assumptions (e.g. goals, unit costs, and macroeconomic and sectoral parameters). Our results are based on the latest available information on infrastructure services coverage and quality, but they can be easily updated as new information becomes available. Future editions of this report hope to incorporate new metrics or dimensions not captured due to lack of information. For those infrastructural components that we did not estimate, the report presents, as a reference and in separate boxes below, information from external sources that should give users an idea of the order of magnitude of the investment needs. Readers will see, for example, how the report treats water storage, ports, and the electrification of bus fleets.

The calculation model we used to quantify the investments to close the infrastructure gaps is available to all interested parties. Specialists or policymakers can thus modify the calculation assumptions and render a sensitivity analysis of the estimates. The model can be downloaded from **https://interactive-publications.iadb.org/La-brecha-de-infraestructura-en-America-Latina-y-el-Caribe**

MAIN FINDINGS

This report finds that Latin America and the Caribbean (LAC) needs to invest USD 2,220.7 billion in water and sanitation, energy, transportation, and telecommunications infrastructure. Of that total, new infrastructure requires allocations of 59 percent, while 41 percent should go to maintaining existing assets and replacing assets that are obsolescent. Infrastructure will require at least 3.12 percent of the region's GDP every year until 2030.

A country-by-country analysis, using the IDB's regional groupings, shows investments breaking down as follows:

- the CID countries of Central America (Haiti, Mexico, Panama, the Dominican Republic and others): USD 612.8 billion;
- the CCB countries of the Caribbean: USD 19.6 billion;
- the CAN countries of the Andean region: USD 457.9 billion; and
- the CSC countries of the Southern Cone: USD 1,130.4 billion.

Relative to population, the region will need to invest USD 282 per capita per year up to 2030. In the Southern Cone countries (CSC), investment needs amount to USD 322 per capita, followed by those of the Andean and Caribbean groups (CAN and CCB) with 259 and USD 251 per capita per year, respectively, and the countries of Central America (CID) at USD 243 per capita.

Table ES.1. *Investment needs through 2030 to meet the infrastructure component of the SDGs in Latin America and the Caribbean, by IDB region (USD billions)*

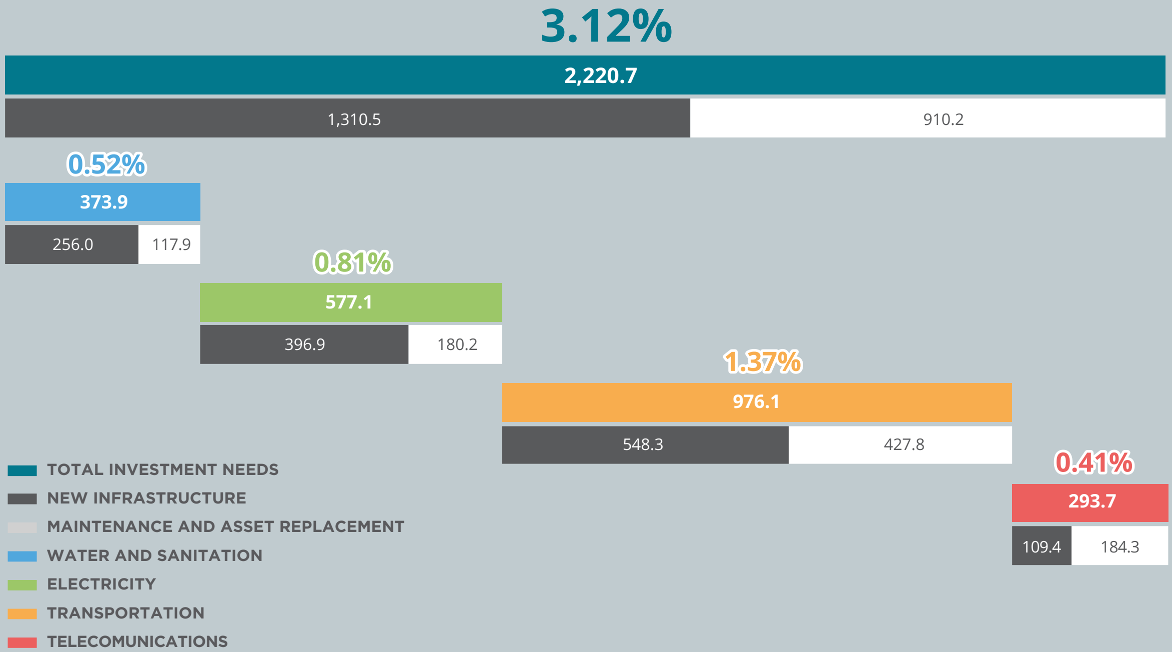
REGION	COUNTRIES	NEW INFRASTRUCTURE SPENDING	MAINTENANCE AND ASSET REPLACEMENT	TOTAL	ANNUAL PER CAPITA (USD)
Central American countries (CID), plus Haiti, Mexico, Panama, and Dominican Republic	Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic	382.7	230.1	612.8*	**243***
Caribbean Group countries (CCB)	Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago	10.0	9.5	19.6*	**251***
Andean Group Countries (CAN)	Bolivia, Colombia, Ecuador, Peru, and Venezuela	283.3	174.7	457.9*	**259***
Southern Cone Countries (CSC)	Argentina, Brazil, Chile, Paraguay, and Uruguay	634.6	495.9	1,130.4	**322**
Total (Latin America and the Caribbean)		**1,310.6**	**910.2**	**2,220.7**	**282**

Source: Authors' elaboration.

*** Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay. In addition, the Annex has detailed country-level information on the investment needs and information availability for the calculation of the gap for each service. For CID and CCB countries and Venezuela, lack of information drives the calculation down.**

A sector-by-sector analysis shows that closing the access gap and maintaining assets in the **water and sanitation sector** requires an annual average investment of 0.5 percent of regional GDP. In the **electricity sector**, Latin America and the Caribbean should invest annually 0.8 percent of its GDP to provide universal access to electricity and to begin decarbonization of its electricity generation mix according to the country expansion plans. In the **transportation sector**, building the needed infrastructure for roads, airports, and public transportation would mean an annual investment of 1.4 percent of the region's GDP. Finally, in the **telecommunications sector**, boosting residential connectivity with fixed broadband and 4G mobile internet technologies would require an average annual investment of 0.4 percent of GDP through 2030.

Figure ES.1. *Annual required investment as a percentage of regional GDP, per sector (total investments, 2019–30, USD billion)*

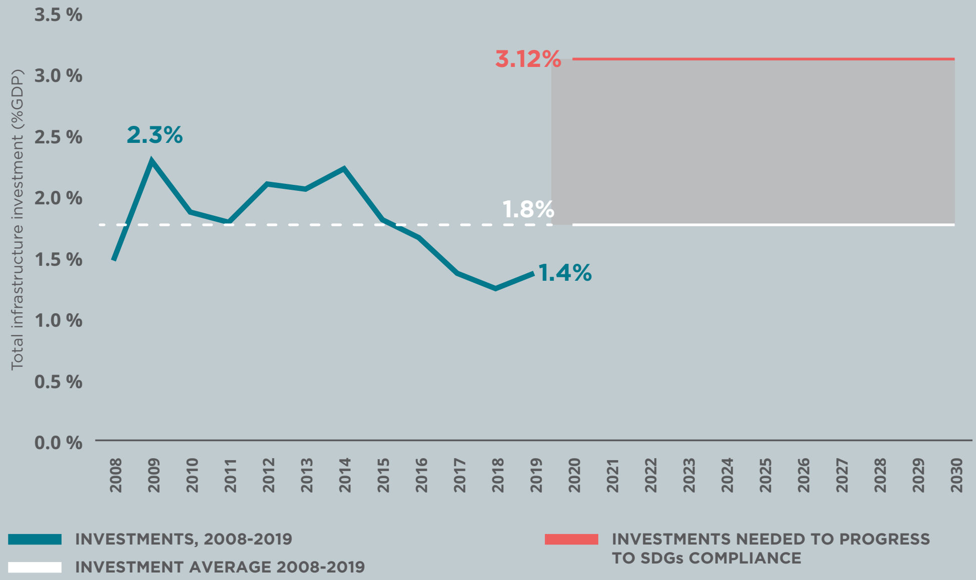


Source: Authors' elaboration.

To close its infrastructure gap, the region will need to boost investment by more than 70 percent, from 1.8 percent of GDP (average of investments in the 2008–19 period) to 3.12 percent. Figure ES.2, below, shows infrastructure investment for the 2008–19 period[1], projects its average, and compares it with the investment needs (3.12 percent of GDP) estimated in this report. An increase of this magnitude in infrastructure investment poses a challenge for the region, as its economic and fiscal space have been affected[2], and infrastructure investments are lower due the COVID-19 pandemic and the related economic downturn.

1 GDP information was obtained from the IMF's WEO, April 2021. To estimate public investment, we used investment amounts data for the region in current U.S. dollars (USD) from Infralatam. Private investment amounts were taken from investments in physical assets reported on the World Bank's Private Participation in Investment (PPI) database and complemented with our own estimations for countries which are not in the database. For Chile and Uruguay, we re-estimated calculations found in the *Infrastructure Journal* for 2018 and 2019 based on the 2015–17 average. For Panama, we used private investment relative to GDP reported in the 2020 edition of Development in the Americas (0.7 percent) (Cavallo, Powell, and Serebrisky, 2020). Finally, the quotient relative to GDP is the sum of private and public investment relative to the GDP reported by the IMF.
2 See Izquierdo *et al.* (2020).

Figure ES.2. *LAC's investment gap: Comparing actual vs. necessary regional investment in infrastructure (annual investment as a percentage of GDP)*

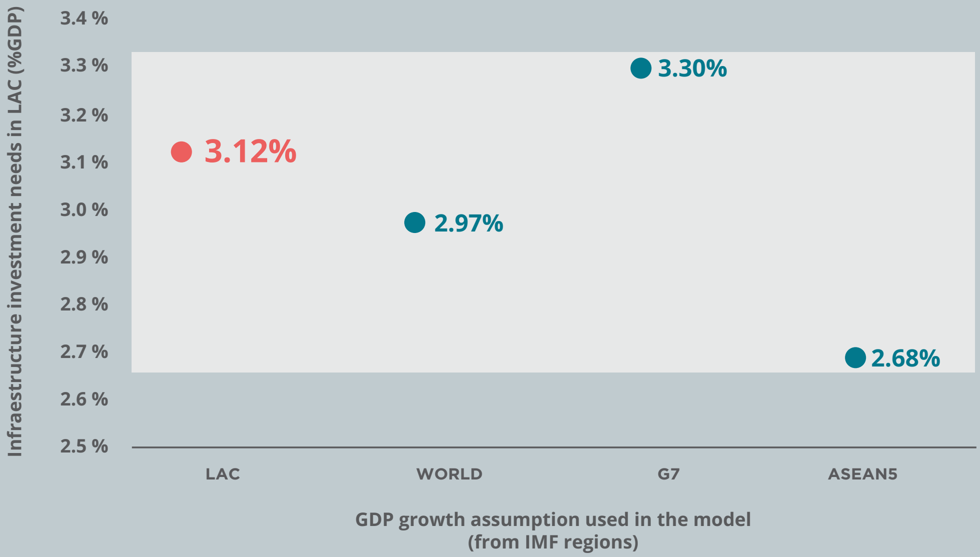


Source: Authors' elaboration based on information from INFRALATAM, the World Bank, and the Infrastructure Journal.

The level of annual investment needed to close the infrastructure gap by 2030 as a percentage of GDP depends on the expected economic growth: the more the economy grows, the lower the estimate will be. The estimated value of annual investment needs reported in this document is 3.12 percent of GDP; this result uses the International Monetary Fund's projections, which estimate that LAC's GDP will grow 2.4 percent annually.[3] Figure ES.3 presents a sensitivity analysis of the estimation of investment needs with different GDP growth rates. The area in white shows the range of investment needs assuming the growth rates of different country groupings as defined by the IMF. Thus, if the region grew at the rate of the G7 economies[4] (1.4 percent), the resources that Latin America and the Caribbean should allocate annually to infrastructure investment would increase to 3.3 percent of GDP; whereas if it were to grow at higher rates, such as the one expected for the ASEAN-5[5] countries (5.4 percent), the investment needs would fall to 2.7 percent of GDP.

3 The Annex provides more information on growth projections.
4 G7 countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.
5 ASEAN-5 countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

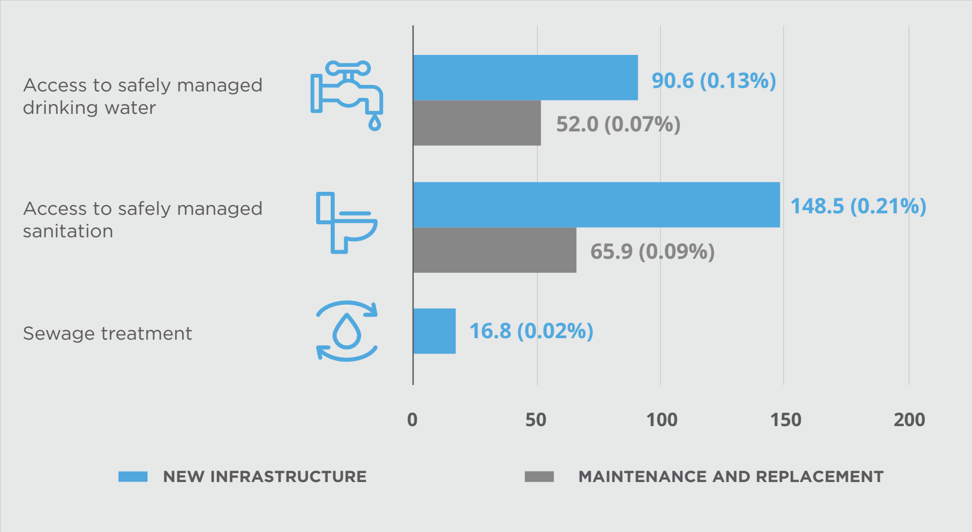
Figure ES.3. *Investments that LAC would have to make to close the infrastructure gap under various growth-rate assumptions (annual investment as percentage of regional GDP)*



Source: Authors' elaboration.

The region's water and sanitation sector requires USD 373.9 billion of total investments. SDG-6 guidelines ask countries to "ensure availability and sustainable management of water and sanitation for all" by the year 2030. These investments would create universal access to safely managed water and sanitation services by 2030, which includes the treatment of all urban sewage. Of the total, **USD 255.9 billion should be allocated to building new infrastructure to address the current access deficit and the expected growth in demand; USD 117.9 billion would go to asset maintenance and replacement.**

Figure ES.4. *Total investment needs in the water and sanitation sector, in USD billion (annual investments as a percentage of regional GDP)*



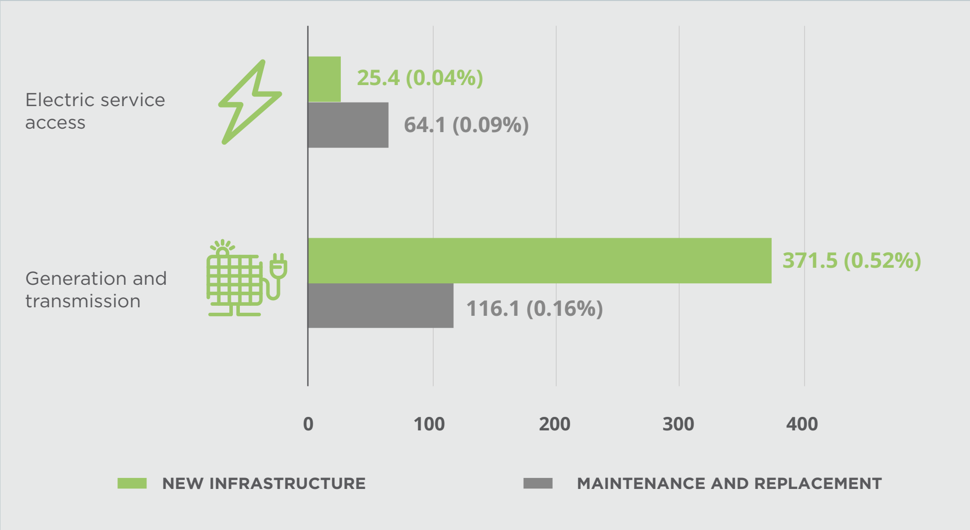
Source: Authors' elaboration.

The region's electricity sector has total investment needs of USD 577.1 billion, a calculation based on SDG-7, which asks countries to "ensure access to affordable, reliable, sustainable, and modern energy for all." These investments would allow the region to expand its distribution networks, or alternative solutions (in rural areas), so that electricity service could reach 100 percent of the population. The spending also includes investments in generation capacity and transmission lines at levels estimated by the IDB's Energy Division[6]. These investments were calculated from LAC country expansion plans, including those needed to decarbonize electricity generation mixes (even if they do not specify that the investments comply with the Paris Agreement)[7]. Our findings show that **closing the gap in the electricity sector would require investments of USD 396.9 billion to build new generation, transmission, and distribution infrastructure; and additional USD 180.2 billion would need to go toward asset maintenance and replacement.**

6 See Yépez-García et al. (2021).

7 In the IDB's Energy Division's estimations, the region's emission-free electricity generation rises from 63.4 percent in 2019 to 70.4 percent in 2030, with large investments in renewable technologies (especially photovoltaic and wind participation, where generation increases from 7.9 to 17.1 percent). But these investments should be seen as falling at the lower bound for climate change mitigation. Also, this scenario may not comply with the profound decarbonization of the economies spelled out in the Paris Agreement, which aims to "limit the global temperature increase well below 2° C above preindustrial levels, while pursuing the means to limit the increase to 1.5ºC above preindustrial levels."

Figure ES.5. *Total investments needed through 2030 in the electricity sector, USD billion (annual investment as a percentage of GDP)*

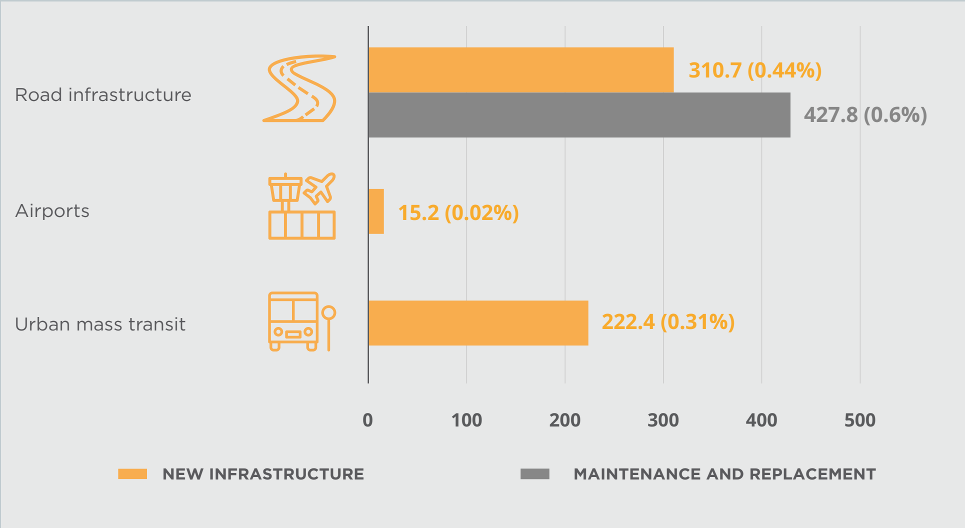


Source: Authors' elaboration.

The total investments needed in transportation were calculated at USD 976.1 billion in reference to SDG-9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation") and SDG-11 ("Make cities and human settlements inclusive, safe, resilient and sustainable"). Several of the SDG targets are multidimensional, while some are qualitative, exceeding the scope of infrastructure investment.

We broke transportation investments into three groups: roads, airports, and urban mass transportation. Investments in roads would seek to guarantee all residents full, year-round access to transitable roadways less than 2 kilometers away. With reference to the World Bank's Rural Access Index, this study offers a "first best" scenario, doubling the LAC's indicator value from 35 percent in 2019 to 70 percent by 2030. For the airport investments, we considered those needed to provide access to all urban centers with 100,000-plus inhabitants. For the urban mass transit gap, in turn, we calculated the investments that would give all cities with 500,000 or more inhabitants the coverage levels seen for cities with the best performance in the region, emphasizing bus rapid transit infrastructure. According to our estimates, **the region should allocate USD 548.3 billion to the construction of new road, airport, and urban mass transit infrastructure, and USD 427.8 billion to maintain and replace road infrastructure.**

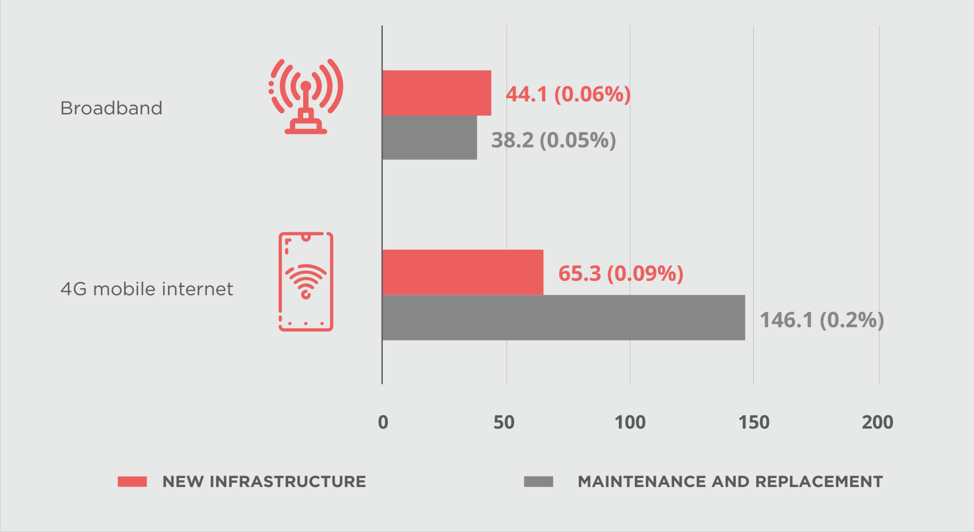
Figure ES.6. *Total investments needed through 2030 in the transportation sector, USD billion (annual investment as a percentage of regional GDP)*



Source: Authors' elaboration.

In the telecommunications sector, we calculated the region's total required investments at USD 293.7 billion by referring to SDG-9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation." One SDG-9 target is specific: "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries." This study considered the regional investments required to attain the access levels seen in the advanced countries of the Organization for Economic Cooperation and Development (OECD). It identifies two technologies associated with access to the Internet: fixed broadband and 4G mobile internet. The findings show that **closing the gaps in the telecommunications sector requires USD 109.4 billion to build new infrastructure to increase connectivity with fixed broadband and 4G standard mobile Internet, and USD 184.3 billion to maintain existing assets and replace assets nearing obsolescence.**

Figure ES.7. *Total investments needed through 2030 in telecommunications, USD billions (annual investment as a percentage of regional GDP)*



Source: Authors' elaboration.

The breakdown of the estimated investment needs by each SDG shows that, of the USD 2,220.7 billion total, **47 percent would go toward SDG-9,** which includes investments associated with road, airport, and telecommunications infrastructure. Next are **investments related to SDG-7, which represent 26 percent of infrastructure investment by 2030. Third, SDG-6 represents investments of around 17 percent of the total.** Finally, **achieving SDG-11 would require urban mass public transportation investments of 10 percent of total estimated investments.**

Figure ES.8. *Investments required to close infrastructure gaps, by SDG*

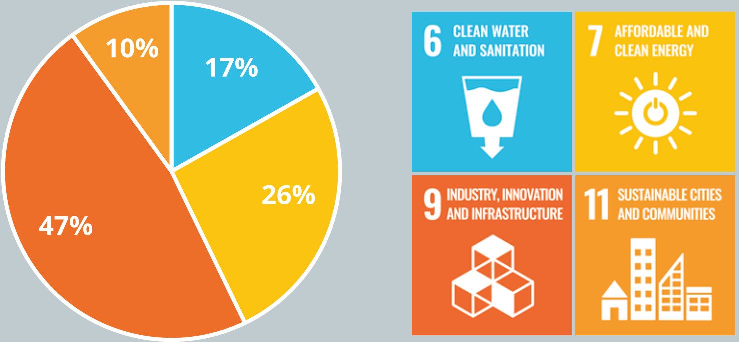


Table ES.2. *"By 2030" investments required to close infrastructure gaps, by SDG*

SUSTAINABLE DEVELOPMENT GOALS (SDGs)	INVESTMENT (BILLION USD)	PERCENTAGE
GOAL 6: Ensure access to water and sanitation for all	373.9	17%
GOAL 7: Ensure access to affordable, reliable, sustainable and modern energy	577.0	26%
GOAL 9: Bild resilient infrastructure, promote sustainable industrialization and foster innovation	1,047.4	47%
GOAL 11: Make cities inclusive, safe, resilient and sustainable	222.4	10%
Total	**2,220.7**	**100%**

Source: Authors' elaboration.

Table ES.3. *"By 2030" LAC investment across SDG infrastructural components, by subsector (USD billions)*

	TYPE OF INVESTMENT	New investment	Maintenance and asset replacement	Total gap	Annual investment needed to close gap (% of GDP)
WATER AND SANITATION	SAFE ACCESS TO WATER (HIGH)	90.6	52.0	**142.6**	**0.20%**
	SAFE ACCESS TO SANITATION (HIGH)	148.5	65.9	**214.4**	**0.30%**
	WASTEWATER TREATMENT	16.8	0	**16.8**	**0.02%**
ELECTRICITY	ACCESS TO ELECTRICITY	25.4	64.1	**89.5**	**0.13%**
	GENERATION AND TRANSMISSION (BASE SCENARIO)	371.5	116.1	**487.5**	**0.69%**
TELECOMMUNICATIONS	FIXED BROADBAND	44.1	38.2	**82.3**	**0.11%**
	4G	65.3	146.1	**211.4**	**0.30%**
TRANSPORTATION	ROADS	310.7	427.8	**738.5**	**1.04%**
	AIRPORTS	15.2	0	**15.2**	**0.02%**
	URBAN MASS TRANSIT (BRT SCENARIO)	222.4	0	**222.4**	**0.31%**
	TOTAL	**1,310.5**	**910.2**	**2,220.7**	**3.12%**

Source: Authors' elaboration.

LIMITATIONS AND POTENTIAL IMPROVEMENTS TO THE ESTIMATES OF INVESTMENT NEEDS

For several reasons, these estimates are the **minimum needed** to close the infrastructure gap for SDGs in Latin America and the Caribbean. First, because we estimated the investments in infrastructure services that are explicitly tied to SDG. But **infrastructure services affect other SDGs**, such as those regarding marine natural resources (SDG-14) and life on land (SDG-15). Additionally, **relevant challenges—climate change is one—cut across all SDGs, affecting infrastructure design and construction and, thus, investment needs.[8] The preliminary estimates presented here do not include complementary efforts required to achieve all the SDGs linked to climate change.** For example, recent estimates for Latin America and the Caribbean suggest that the energy efficiency goals concerning refrigerators could require investments of around USD 8 billion through 2030[9]. The investments needed to electrify public transportation, in turn, **could increase investment needs by more than USD 11 billion, including charging stations and reconfiguring electricity distribution grids.**

Second, the estimates presented here are based on the investments in infrastructure construction; but, as emphasized in the 2020 edition of Development in the Americas (DIA)[10], **the region has ample opportunities to improve service provision with redesigned policies and regulatory institutions.** Better infrastructure software could also improve SDGs metrics and be cost-effective, especially in a post-pandemic era.

Third, we have calculated investment needs according to a standard methodology. The calculation **does not consider other investments that, while needed, require a detailed analysis of conditions at the country, or even city, level**. Included among these investments, for example, are those needed for water collection, reservoirs, and treatment, as well as green infrastructure.

Finally, **investment and maintenance needs could be calculated only for those sectors where we could reasonably estimate the existing infrastructure stock.** For that reason, estimates on asset maintenance and replacement are limited for certain sectors (airports, for example) or rendered only partial elsewhere (for example, existing assets for electricity generation). These limitations push our results to the lower bound.

---

8 Thacker *et al.* (2019) develop an interesting estimate regarding the interaction of multiple SDGs and their relationship to infrastructure to highlight how infrastructure investments affect development patterns for future generations.
9 See Urteaga (2020).
10 Development in the Americas 2020, Inter-American Development Bank. From structures to services: the path to better infrastructure in Latin America and the Caribbean.

This report includes information on studies that estimate infrastructure investments not included in our calculations (see boxes 1, 2 and 3). Their magnitude is relatively small compared with the global figures reported in this study. For example, investments in water storage would entail an annual investment effort of 0.005 percent of regional GDP. For ports and the additional investment for fleet electrification in urban mass transit, annual investment would be 0.02 percent of regional GDP in each case.

Despite these limitations, this report is **a methodologically consistent effort to estimate the LAC's infrastructure gap.** Again, the purpose of this report is to contribute to policymaking with a tool that estimates investment needs. The authors hope and expect that this tool can be improved in its design, methodology, analyzed sectors, and cost estimates. In other words, given the uncertainty regarding not just the costs of infrastructure construction but also the different targets each each country, region, and city may set to become prosperous societies, **we expect this document (and the Excel spreadsheet that goes with it) to be "live" tools that can facilitate decision making.**

1. INTRODUCTION

The COVID-19 pandemic has shown that, despite the progress of the past two decades, Latin America and the Caribbean (LAC) still faces multiple economic, social, and environmental challenges. The path toward development is complicated; it is a journey societies and policymakers undertake amid the imperatives to foster economic growth, reduce social inequality, and restore and sustain the environment.

A condition to achieve those objectives is greater access to high-quality and sustainable infrastructure services. Without improvements in electricity services, it is difficult to foresee a prosperous economic future for the region: More than 30 percent of the region's businesses cite blackouts as a prime difficulty, with annual estimated losses of 2.4 percent of total sales (Enterprise Survey, World Bank, 2019; Acevedo, Borensztein, and Lennon, 2019). Without higher-quality water and sanitation services, it is impossible to imagine inequality lessening in the region: 36 million people still have no piped water to their residences, and every day 60 million residents (mainly affect poor and rural people) have limited access to sanitation services (Joint Monitoring Programme). Reducing the gender gap in the region will also be vital. Yet access to the job market is bedeviled by sexual, verbal, or physical aggression in public transit. LAC studies that show 6 out of 10 women reporting abuse (Cavallo, Powell, and Serebrisky, 2020). Likewise, a healthy, sustainable environment is impossible to guarantee without definitive regional steps toward electromobility. How else can cities reduce emissions generated by internal combustion vehicles, where contaminant particles reduce life expectancy in magnitudes comparable to tobacco use (Greenstone and Fan, 2018)? What if the region cannot increase the participation of renewable energies in its electricity generation mix?

Meeting these challenges requires a holistic vision of reforms to infrastructure services, reforms to revolutionize both the "software" (for example, regulations, competition in service provision, and so forth) and the "hardware" (the assets used to provide these services). The 2020 edition of Development in the Americas (Cavallo, Powell, and Serebrisky, 2020) highlights a set of available reforms focused on service provision, which could improve quality and coverage with current assets. That course of action has its limits: better service access and quality require investment in infrastructure. Quantifying the investments is thus a crucial step. Without it, we cannot understand the scale of the effort going forward—the path of investments to be made and policies to be implemented.

The first step is to set the goals—a difficult task, yes, but required to secure a more promising and inclusive future. This is especially true when competing objectives set up conflict over scarce resources and when fiscal limitations affect public action—a likely scenario for the COVID-19 era (Izquierdo et al., 2020). In line with this thinking, this study uses the United Nation SDGs, set in 2015, as the reference point for estimating the infrastructure gap in LAC. Several reasons led us to select these goals as a guide.

First, the SDGs are a blueprint ensuring a sound path among different desirable aims. Of course, every advance in access to infrastructure services should be celebrated, but experience shows that insufficient advance in access to one service can limit advances (and their benefits) in others. For example, the benefits of increased coverage of telecommunications networks cannot be fully realized if people have scant access to electricity service allowing them to charge cell phones and power digital devices. Another example: access to safe drinking water and sanitation lowers the incidence of disease and saves time otherwise spent on household water-collection. Any resulting productivity gains are limited if people cannot access public transportation to commute to remunerative jobs (Hutton and Haller, 2004; Pickering and Davis, 2012). In the same line, Escobal and Torero (2005) and Urrunaga and Wong (2016) present evidence showing the complementarity of infrastructure in Peru, analyzing the differentiated impacts on poverty levels and social indicators, respectively.

With these factors in mind, the IDB Group established in its 2025 Vision a series of guiding principles and priorities that seek to foster a balanced, inclusive, and environmentally sustainable development. We also selected the SDGs as a guide because they intersect well with 2025 Vision. Guaranteeing access to the infrastructure supporting quality and sustainable services to the region's households and businesses is undoubtedly a condition for a dynamic, digitalized economy, able to increase opportunities among populations made vulnerable by income level, gender, health status, or some other reason. Additionally, developing such infrastructure integrates LAC countries with continental and global value chains.

Finally, the SDGs were selected to guide this study because of their regional scope. Each country has its own local goals or targets. But the SDGs are regionally shared, facilitating comparisons among countries and subregions. In this sense, and even if SDGs are not binding commitments for IDB member countries, they are an internationally recognized aspirational reference.

After this introduction, Section 2 describes the methodology for the report, detailing its advantages vis-à-vis other methodologies for calculating gaps. We then present analyses of the services and present the results of the infrastructure-gap exercise for water and sanitation (Section 3), electricity (Section 4), transportation (Section 5), and telecommunications (Section 6). In Section 7 we discuss the limitations—of the estimates and of the assumptions—which are important for the correct interpretation of the results. Section 8 presents aggregate results and conclusions.

2. HOW WE ESTIMATE THE INFRASTRUCTURE GAP

A first possible method for assessing the infrastructure gap involves estimating investments that would maximize economic growth. This approach has led to macroeconomic estimates in which growth is a function of infrastructure stock. This assumes a certain homogeneity in the stock, which accrues to an economy. Infrastructure is inherently heterogeneous, however, and subject to network effects that make it hard (or even impossible) to determine the marginal effects of increased investment. For example, building a bridge can affect productivity and growth depending on its locale, existing transport networks, and the capacity and efficiency of the logistics services using the bridge. Additionally, it would be difficult to argue, for example, that smaller investments in water treatment plants would have a similar impact on economic growth.

An alternative approach would assess investment needs from a series of determinants. Based on available historical information, we could establish a link between those determinants and the infrastructure stock using econometric methods. The idea is to capture the relationship between economic growth and infrastructure needs (considering and correcting for other conditions, such as demographic, social, and geographical factors), starting with the assumption that the existing relationship is adequate and stable over time. The difficulty here is that if these assumptions are faulty, the estimates will have little relation to future infrastructure demands.

Apart from the difficulties inherent in both approaches —for a discussion of the challenges in estimating infrastructure gaps in the United States, see Glaeser and Poterba (2021)—, these aggregate methods (also called "top-down" approaches) have other problems. These relate to the absence of stable relationships among the economic performance indicators on the one hand and, on the other, the impact of these indicators when infrastructure is built. Additionally, these methods provide scant information for those making policy decisions. First, because they do not consider other plausible goals (beyond the economic factors) that could justify new infrastructure. For example, in a world challenged by climate change, investment in renewable energy generation is generally guided by the need to reduce emissions rather than by the need to promote economic growth. Second, aggregate-level results do not tell us which actions will close the identified gaps, nor do they point to the critical sectors where investment needs to be focused. Yes, we get to know the annual investment needs in infrastructure, but we do not know if we should invest in safe drinking water or new airports. Even when these estimations are done at the sector level, we still need to identify *the type of investment*.

The alternative is taking the opposite approach, known as bottom-up, where the procedure is first to establish an explicit, achievable goal (both quantitatively and qualitatively) and then valuate the investments needed to attain it. The World Bank (Rozenberg and Fay, 2019) recently adopted this approach to infrastructure gaps in the developing world. It resembles IDB methods to estimate the gaps noted in national infrastructure plans for Peru (2019) and the Dominican Republic (2020). This bottom-up approach allows for an approximation of investment needs in modular fashion—the total being the sum of gaps identified for each sector, country, and region, in closing gaps in access, service quality, and sustainability.

The estimates in this study were calculated with reference to the "by 2030" goals embedded in the SDGs, where they are linked to infrastructure sectors. This breakdown of the infrastructure gap allows us to propose various helpful scenarios and to modify parameters like the unit costs of infrastructure. This is particularly relevant for estimating investment needs for infrastructure: The standards applied to a service can affect investment amounts. Again, the aim is to derive helpful scenarios for decision makers. Following Rozenberg and Fay (2019), an "if-then" format helps decision makers because goals and standards are established, so this methodology becomes a tool to calculate investment amounts.

There is an additional advantage of this modular approach to assessing infrastructure investments. It identifies the investments needed to maintain assets and to replace those that are obsolescent (or obsolete)—hardly minor concerns. The World Bank's 2021 report for the G-20 posits that untrustworthy service provision in infrastructure hampers both economic growth and the welfare of users (World Bank, 2021). The report also asserts that policy action must address maintenance and replacement issues: digitalization and climate change render economies more vulnerable to service disruptions. This study helps to quantify the investments needed to implement adequate maintenance of the infrastructure stock. This key step will orient public policy on infrastructure so the region can attain the SDGs by 2030.

We should note that the SDGs do not always provide clear metrics for our methodology. Where the SDGs are unclear and prevent explicit calculations, we defined alternative targets consistent with the pertinent SDGs. In those cases, however, some discretion is required given the lack of indicators for SDGs. The authors therefore propose a series of indicators compatible with the SDGs and for whose calculation there is available information. The definitions and the sources of information we used, the calculation mechanisms, and the assumptions used for calculating the gap in each of the sectors are detailed in the Annex.

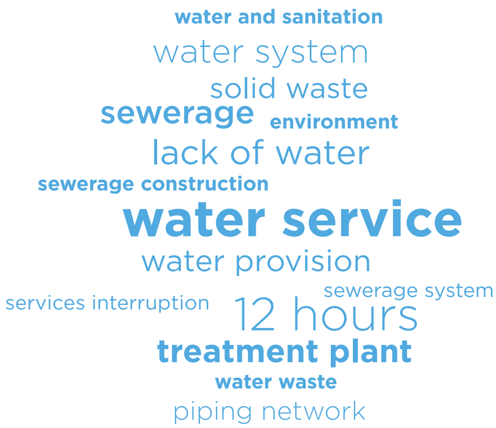
3. REACHING THE SDGs IN WATER AND SANITATION SERVICES

ANALYZING WATER AND SANITATION SERVICES IN THE REGION

Access to water and sanitation services is one of the most pressing challenges facing relegated nations. Improvements can be measured in saved lives, lower incidences of gastrointestinal diseases, better school (and work) attendance, and productivity gains for businesses, among other various dimensions vital for development.

LAC citizens know how lack of access affects their lives and productivity. A recent analysis of the IDB's Knowledge, Innovation, and Communication (KIC) Sector, captured the key words that social media users (Twitter) used from 2016 to 2018 to describe LAC infrastructure services. The goal of the KIC study was to characterize user interactions regarding water and sanitation to create a word cloud. The language study confirmed that comments on service provision, such as continuity and potability, dominated user exchanges (figure 1).

Figure 1. *Digital conversations regarding water provision services in LAC*



Source: Calderón, Fernández Gómez Platero, and Wanner, 2020.

Household perceptions also reflect poor service quality in the region. According to the IDB–LAPOP survey, in 2018 the average household in LAC had access to water, on average, 18 hours per day; from Costa Rica's nearly uninterrupted service to Guatemala's average of just 13 daily hours. Even when drinking water coverage is around 80 percent for most countries, less than 60 percent of respondents say they drink water from the faucet. In this regard, Mexico is an extreme case. With the country at 81 percent coverage, only 16 percent of Mexicans say they drink water from the faucet (Cavallo, Powell, and Serebrisky, 2020).

Lack of access to drinking water and sanitation is detrimental not only to the lives of citizens, and especially those of the poor, who have fewer alternatives: it also affects business productivity in the region. According to the World Bank's Enterprise Survey, 16 percent of the region's businesses stated that they experience recurring insufficiencies in water provision (table 3.1). When compared with the rest of the world's developing regions with respect to this indicator, LAC is ahead only of Sub-Saharan Africa and the Middle East and North Africa.

Table 1. *Insufficient water provision to businesses (in percentages, by region)*

REGION	PERCENTAGE OF BUSINESSES
Europe and Central Asia	6.7
East Asia and the Pacific	10.2
South Asia	11.3
Latin America and the Caribbean	**15.9**
Middle East and North Africa	19
Sub-Saharan Africa	22.7

Source: World Bank Enterprise Survey, 2019.

It is not all bad news for water and sanitation services in the region, though. Over the past two decades, LAC has taken great strides in service access, although the region's progress is diminished by the lower quality standards with which this access was achieved.

To evaluate the progress in achieving the 2015 Millennium Development Goals (MDGs), we considered households to have access to "improved" water if they had pipeline water or water from a protected source (for example, boreholes or tube wells, protected wells or springs). According to the 2018–19 AmericasBarometer survey conducted by LAPOP, urban households in this category reached 96.7 percent. But in 2015 the relevant SDG raised the standard to "safely managed drinking water"—that is, drinking water from an improved source, available on the premises (generally, inside the dwelling), available when needed and free of contamination. Universal access to safely managed water by 2030 is an ambitious goal: it requires not only substantial effort and expenditure but also data that we do not possess. Data would permit evaluations of the present situation, suggest some solutions, and allow progress to be monitored (Bain *et al*., 2018).

Analyzing data on intermediate access gives an idea of the task ahead. For example, moving the access threshold from "piped water in any available source" to "piped water within the dwelling" causes figures for access to plunge (figure 2, panel A). Access is much worse in rural areas, regardless of how it is defined. There are also important differences between the poorest and richest households, especially in Argentina, Bolivia, Brazil, Costa Rica, El Salvador, and Mexico (Gómez-Vidal, Machado, and Datshkovsky, 2020).

Sanitation solutions differ with locale. On the one hand, urban areas are generally more suited for sewage networks that are connected to a treatment plant. On the other hand, rural households require solutions on a smaller or individual scale (septic tanks or compost latrines), given that households are few and far between. See figure 2 (panel B) for urban and rural rates of access to sanitation.

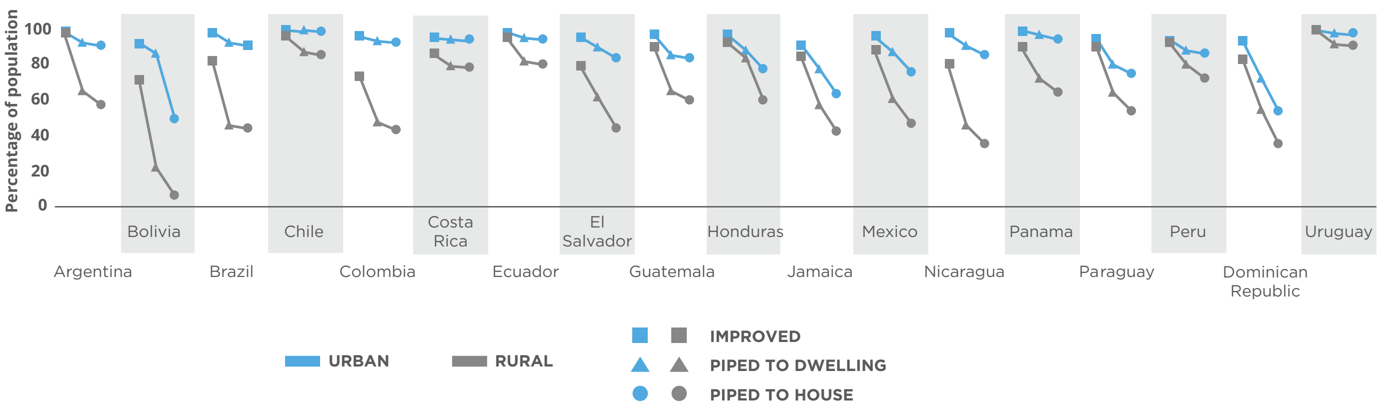
With the SDGs, the access-to-sanitation standard rose in relation to MDGs, as it did with water access. The MDGs introduced the concept of improved sanitation, including measures to avoid human contact with excreta and shared household facilities. The SDGs raised the standard to what we now refer to as "safely managed" sanitation, which requires human excreta to be safely disposed of in situ or removed and treated offsite.

The 2018–19 Americas Barometer Survey shows that, "quality" definitions aside, access to sanitation services is lower than access to water across the region. Increasing service coverage in informal settlements in urban and peri-urban zones is an important challenge. Unplanned population expansion, rudimentary housing construction, and lack of own housing hinder the adoption of conventional solutions.

If connection rates are low, the amount of waste collected and treated is even lower. In the region, only about 30 percent to 40 percent of collected wastewater is treated (World Bank, 2019). Regionally, only Sub-Saharan Africa and South Asia fare worse than LAC in this regard. The few exceptions are Chile, where access rates rose to 100 percent in 2012 (it was 21 percent in 2000), and Mexico, where treated wastewater increased from 23 percent in 2000 to close to 63 percent in 2017 (OECD, 2017).

Figure 2. *Access to water and sanitation services, in selected LAC countries*

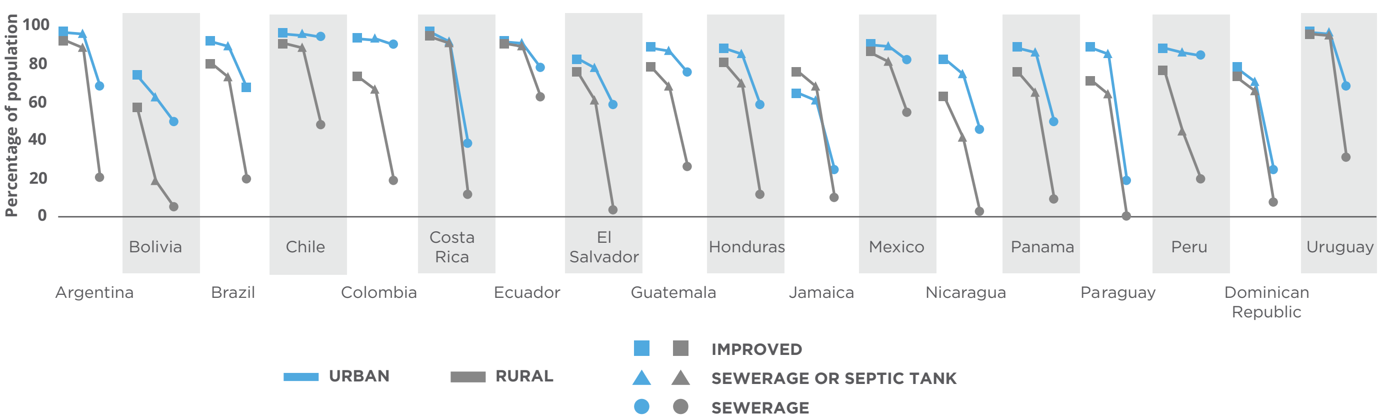
PANEL A. ACCESS TO WATER



Source: Cavallo, Powell, and Serebrisky, 2020.

Note: "Improved water" comes from pipes, protected wells, rainwater, or protected springs. "Piped to dwelling" means either into the yard or into the house. "Piped to house" means into the house.

PANEL B. ACCESS TO SANITATION



Source: Cavallo, Powell, and Serebrisky, 2020.

Note: Improved sanitation involves either a flush toilet or latrine that separates excreta from human contact and is used by only one household. "Sewerage and septic tank" describes a sanitation system that removes excreta from wastewater via sewage pipes or septic systems. "Sewerage" refers to a sanitation system that connects households to sewage pipes.

Access to water and sanitation services is one of the most pressing challenges facing relegated nations.
/ P. **05**

ESTIMATING THE INFRASTRUCTURE GAP AFFECTING WATER AND SANITATION SERVICES

Estimations of the infrastructure gap for water and sanitation services includes three modules: access to safe drinking water, access to safe sanitation, and the infrastructure gap for wastewater treatment plants.

The infrastructure gap affecting the supply of drinking water

The SDG delimitation on safe drinking water is clear: universal access to "safely managed" water by 2030. In this case, the relevant SDG is SDG-6, and the relevant target 6.1, which declares the need by 2030 to "achieve universal and equitable access to safe and affordable drinking water for all." The specific indicator to monitor the progress on this target is the proportion of the population with access to safely managed drinking water services. This target has associated investments to provide access and includes the need to invest in qualitative aspects of the service.

To estimate access rates, we used information from the World Health Organization's Joint Monitoring Programme (JMP). Implemented by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), the JMP allows researchers to break down access rates under the various WHO standards set for urban and rural areas. For a better reference, the next table has the JMP service ladder for drinking water, including the different classifications and their definitions.

Table 2. *JMP service ladder for drinking water*

Safely managed	Drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority contamination.
Basic	Basic Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing.
Limited	Drinking water from an improved source where collection time exceeds 30 minutes for a roundtrip, including queuing.
Unimproved	Drinking water from an unprotected dug well or unprotected spring.
Surface water	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation channel.

Source: Joint Monitoring Programme (WHO and UNICEF, 2017).

Note: Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs and packaged or delivered water.

The first difficulty this calculation presents is that the JMP does not report access rates to "safely managed" water for each LAC country. To overcome this limitation, we referred to our own, complete information on LAC access to evaluate a series of assumptions. The first assumption appears to be that, for no-information countries monitored by JMP, households with access met the "safely managed" water standard. We believe this underestimates the infrastructure gap. Consequently, any values for the infrastructure gap should be construed as indispensable minimums. An alternative approach could assume that, in this group of countries, households with "basic" water require investments to reach the "safely managed" target set by the SDG. In other words, we assume that the basic-access population has no access to safely managed water. In this case, we may overestimate the real gap because some households with basic water access might also have access to safely managed water. Consequently, the infrastructure gap estimated with this working assumption should be considered maximum amounts.

In short, we have circumscribed the range of needs for calculating the investment required by 2030 to meet target 6.1 of SDG-6.[11] The constraints posed by lack of information are negligible since countries with available information about access to safely managed water account for 80 percent of the region's population.

Once we determined the number of LAC households with no access to "safely managed" drinking water, we then estimated the investments needed through 2030 to secure SDG-6 infrastructure. We had to assign the cost of connecting existing households (and of new households due to population growth) to safely managed water supply. To estimate costs, we used multiple sources, including expert opinion, IDB projections, and academic papers. For example, Hutton and Varughese (2016) present unit costs for the provision of drinking water and sanitation in 24 LAC countries under the various quality standards.[12]

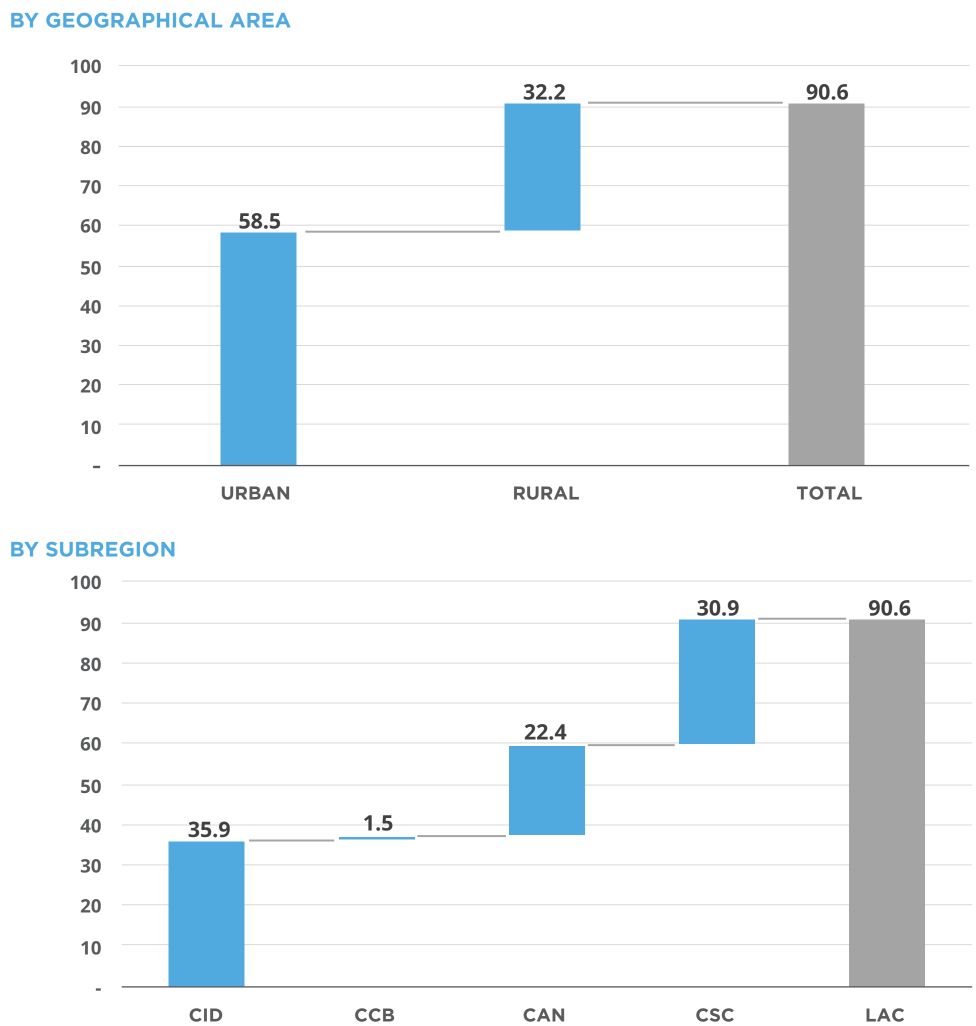
This analysis concludes that the region needs to invest between USD 64.5 and 90.6 billion in new infrastructure to guarantee universal access to safely managed water by 2030, depending on the investment scenario. Around two-thirds of this amount should be invested in urban areas; although, as the analysis showed, rural access rates are lower and the absolute number of urban inhabitants without access to services is higher. On top of that, migration trends to 2030 show that rural-to-urban migration will increase urban investment needs even more.

---

11 A third option would be to set a value between the two extreme assumptions, although this would be an arbitrary exercise. Our knowledge of the LAC sector leads us to conclude that, for countries that provide no data on access, people have only basic access, not "safely managed water." Consequently, additional investments will be needed.

12 The Annex includes the list of the sources used (and the details of the values considered) to calculate the gap.

Figure 3. *Total investments needed in new infrastructure through 2030 to ensure access to safe drinking water (maximum investment scenario, in USD billions)*



Source: Authors' elaboration.

Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay.

To reach universal access to safe drinking-water services, the region needs to invest in more than new infrastructure. It needs to maintain existing assets and replace assets that are obsolete or obsolescent. To achieve SDG-6 (safe drinking water) in this fashion, the region needs to invest an additional USD 44.4–52.0 billion by 2030 (see the Annex for assumptions), depending on the investment scenario. Consequently, the minimum scenario entails investments of USD 108.9 billion, while the maximum scenario has that number at USD 142.7 billion. This maximum-investment scenario translates into average annual investment of around 0.2 percent of regional GDP. The investment needs for each country in the region are summarized below in table 3.

Table 3. *Total investments needed through 2030 to close the infrastructure gap affecting access to safe water, by country (maximum investment scenario, in USD billions)*

COUNTRY	INVESTMENT NEEDS		
	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	8.07	4.23	**12.30**
Bahamas	0.08	0.04	**0.12**
Barbados	0.05	0.03	**0.08**
Belize	0.12	0.05	**0.16**
Bolivia	2.93	1.32	**4.25**
Brazil	20.46	16.26	**36.72**
Chile	0.96	1.15	**2.11**
Colombia	5.29	3.60	**8.89**
Costa Rica	0.45	0.36	**0.80**
Ecuador	2.40	1.30	**3.70**
El Salvador	1.48	0.70	**2.18**
Guatemala	4.12	1.69	**5.81**
Guyana	0.21	0.09	**0.30**
Haiti	3.93	1.38	**5.30**
Honduras	2.94	1.18	**4.12**
Jamaica	0.71	0.33	**1.03**
Mexico	18.00	9.59	**27.59**
Nicaragua	1.28	0.50	**1.78**
Panama	1.11	0.50	**1.61**
Paraguay	1.26	0.60	**1.86**
Peru	5.34	2.59	**7.94**
Dominican Republic	2.44	1.18	**3.62**
Suriname	0.13	0.06	**0.19**
Trinidad & Tobago	0.30	0.14	**0.44**
Uruguay	0.15	0.23	**0.38**
Venezuela	6.41	2.95	**9.36**
Total	**90.62**	**52.04**	**142.66**
Annual investment (% of GDP)	**0.13%**	**0.07%**	**0.20%**

Source: Authors' elaboration.

The infrastructure gap affecting sanitation services

The relevant SDG to calculate the infrastructure gap for sanitation services is also SDG-6. Target 6.2 states the need to "achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations." The specific indicator to monitor the progress on this target is the percentage of the population with access to safely managed sanitation services.

To estimate access rates, we again turned to the Joint Monitoring Programme for Water Supply and Sanitation, managed by WHO and UNICEF. The JMP information allows us to break down the access rates under the different standards set by the organization, both urban and rural. For a better reference, table 4 shows the JMP ladder on access, including the different classifications and their definitions. .

Table 4. *JMP service ladder on access to sanitation*

Safely managed	Use of an improved sanitation facility which is not shared with other households and where excreta are safely disposed in situ or transported and treated off-site.
Basic	Use of improved facilities which are not shared with other households.
Limited	Use of improved facilities shared between two or more households.
Unimproved	Use of pit latrines without a slab or platform, hanging latrines and bucket latrines.
Open defecation	Disposal of human faeces in fields, forest, bushes, open bodies of water, beaches or other open spaces or with solid waste.

Source: Joint Monitoring Programme (WHO and UNICEF, 2017).

Note: Improved facilities include: flush/pour flush to piped sewer system, septic tank or pit latrine; ventilated improved pit latrine, composting toilet or pit latrine with slab.

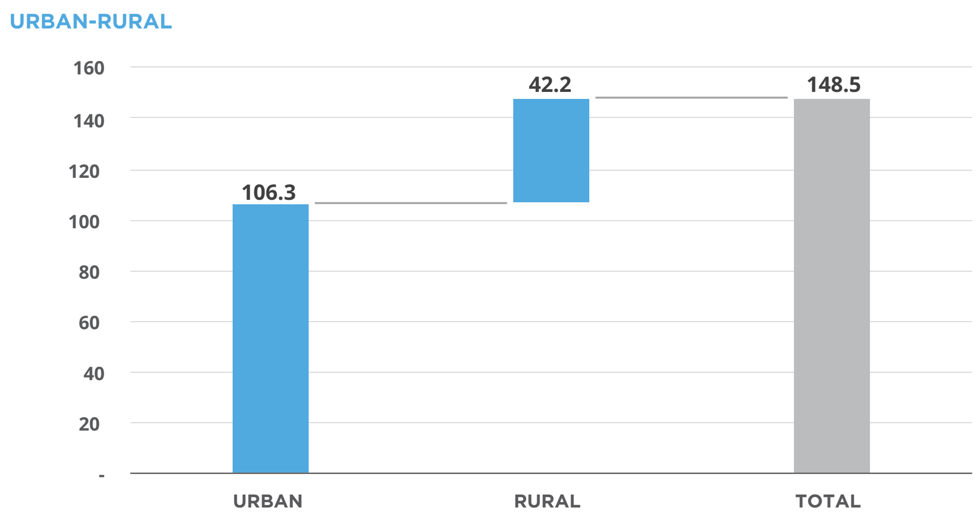
As with drinking water, the JMP does not report access rates to "safely managed" sanitation for all the countries in the region. Given that we do have complete information on access for every country, we made assumptions analogous to those we used for drinking water to define the range of investments required to meet target 6.2 of SDG-6 by 2030.

Having defined the number of LAC households lacking access to safely managed sanitation, we need to estimate the investment required to close the infrastructure gap. To accomplish this, we established the cost of running new connections both to those with no access and to new households formed as a consequence of population growth by 2030.

To estimate each of the relevant costs, we used multiple sources, from expert opinion to IDB projects in the region, and academic papers. See, for example, the Hutton and Varughese (2016) study on 24 LAC countries, which shows the unit costs involved in building to meet target 6.2 of SDG-6 by 2030; the different quality standards are also taken into consideration.[13]

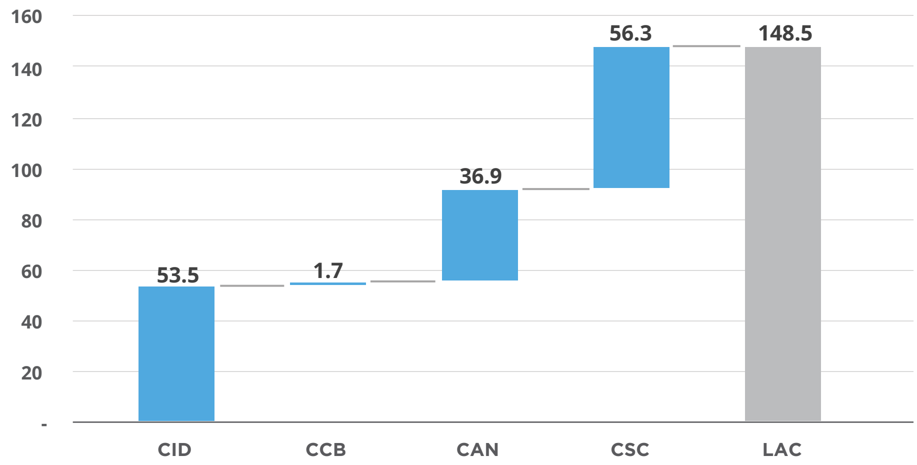
This analysis concludes that, depending on the investment scenario, the region needs to invest USD 128.8–148.5 billion in new infrastructure to guarantee universal access to safely managed sanitation by 2030. Around 70 percent of this amount should be invested in urban areas; although rural access rates are lower, the absolute number of urban inhabitants lacking access is higher. The studies we consulted suggest securing connections could be more expensive in urban than in rural settings, where decentralized solutions are possible. Additionally, trends to 2030 show that rural-to-urban migrations will increase urban investment needs in sanitation.

Figure 4. *Total investments needed in new infrastructure through 2030 to ensure access to safe sanitation services (maximum investment scenario, USD billion)*



13 The Annex lists the sources we used and the details of the values considered in calculating the gap.

BY REGION



Source: Authors' elaboration.

Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay.

Universal access to "safely managed" sanitation services cannot, however, be attained solely with investments in new infrastructure; existing assets must also be maintained, and obsolescent assets replaced. To maintain and replace sanitation assets to meet SDG-6, the region should invest an additional USD 60.1–65.9 billion by 2030 (see the Annex for details on assumptions), depending on the investment scenario. Consequently, the minimum scenario entails the need to invest USD 188.9 billion; whereas in the maximum scenario that number rises to USD 214.4 billion. In the maximum investment scenario, average annual needs are 0.3 percent of regional GDP. The following table summarizes the investment needs for LAC overall and for each country in the region.

Table 5. *Total investments needed through 2030 to close the infrastructure gap affecting access to safely managed sanitation, by country (USD billions, maximum investment scenario)*

COUNTRY	INVESTMENT NEEDS		
	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	12.04	5.36	**17.40**
Bahamas	0.11	0.05	**0.16**
Barbados	0.07	0.04	**0.10**
Belize	0.14	0.06	**0.20**
Bolivia	4.40	1.54	**5.94**
Brazil	40.13	19.84	**59.97**
Chile	1.70	1.34	**3.04**
Colombia	12.77	5.31	**18.08**
Costa Rica	1.41	0.67	**2.08**
Ecuador	4.10	1.80	**5.90**
El Salvador	2.28	0.97	**3.25**
Guatemala	9.08	3.15	**12.23**
Guyana	0.24	0.11	**0.35**
Haiti	6.24	1.97	**8.21**
Honduras	3.31	1.28	**4.58**
Jamaica	0.82	0.39	**1.20**
Mexico	23.62	11.41	**35.03**
Nicaragua	2.45	0.88	**3.34**
Panama	1.52	0.62	**2.15**
Paraguay	1.62	0.74	**2.36**
Peru	8.55	3.39	**11.94**
Dominican Republic	3.47	1.45	**4.92**
Suriname	0.18	0.07	**0.26**
Trinidad & Tobago	0.34	0.16	**0.50**
Uruguay	0.80	0.42	**1.21**
Venezuela	7.13	2.86	**9.99**
Total	**148.50**	**65.88**	**214.38**
Annual investment (% of GDP)	**0.21%**	**0.09%**	**0.30%**

Source: Authors' elaboration.

The infrastructure gap affecting wastewater treatment

Finally, what infrastructure investments are required for wastewater treatment plants? Target 6.3 declares the need to halve the proportion of untreated wastewater. But that target could conflict with the previous one, which seeks to guarantee universal access to safe sanitation, requiring that excreta be "conducted outside the household for its treatment." Hence, this module considered the need to provide treatment plants for 100 percent of the effluents generated in urban settings, with the understanding that in rural contexts in situ treatments exist at the individual or communal level.

To estimate the investment needs, we used information on the percentage of treated wastewater reported by the World Health Organization on the webpage monitoring SDG 6.3.1.[14]

We assumed that each technological solution would contribute equally to closing the gap. We then used the unit costs of each of the available technologies to provide the required solutions in the region.[15] We thus found that to meet the target of SDG-6, the countries with available information will need to invest around USD 16.8 billion in new wastewater infrastructure up to 2030. We do not include information on investment needs in maintenance and asset replacement; existing infrastructure stock is too difficult to quantify, its value is highly sensitive to the type of technology used.

Table 6. *Total investments needed through 2030 to close the infrastructure gap affecting wastewater treatment (USD billions)*

COUNTRY	INVESTMENT NEEDS (NEW INFRASTRUCTURE)
Argentina	2.2
Brazil	7.5
Chile	0.3
Colombia	2.0
Ecuador	0.6
El Salvador	0.2
Mexico	3.0
Peru	1.0
Total	**16.8**
Annual investment (% of GDP)	**0.02%**

Source: Authors' elaboration.

Note: See the Annex for detail regarding countries without available information.

Source: Authors' elaboration.

14 We calculated the gap in wastewater treatment only for the countries covered by the WHO webpage: Argentina, Brazil, Chile, Colombia, Ecuador, El Salvador, Mexico, and Peru. Although the wastewater treatment gap is thus underestimated, the impact of these omissions is softened because these countries represent 80 percent of the region's population estimated for 2030.

15 The Annex includes the sources for the unit costs and the calculation methodology for the estimations.

This module considered the need to provide treatment plants for 100 percent of the effluents generated in urban settings, with the understanding that in rural contexts in situ treatments exist at the individual or communal level.

/ P. **18**

Final comments on bridging the gap affecting water and sanitation services

The estimates of the three water and sanitation modules in the sector tell us that, to attain the targets in SDG-6 by 2030 to guarantee safe universal access to drinking water and sanitation services, the region will need to build new infrastructure totaling USD 256 billion. Of this total, USD 183.8 billion would go toward closing the infrastructure gaps and USD 72.2 billion to build the infrastructure to meet increased demand. Moreover, 70 percent of these investments correspond to urban areas and 30 percent to rural. If we add the costs of maintaining assets and replacing those that are obsolete, this effort would require an average annual investment of 0.5 percent of regional GDP.

The estimates reveal a crucial issue. To evaluate investment needs, quality standards must be defined for the services to be provided. And the impact is substantial: according to these estimates, guaranteeing access at the SDG (not MDG) standards means a 120 percent increase. So, for the policy goals defined by each country to be viable, cost-effective solutions must be designed for the various users.

One final note: This investment gap does not address the additional investments necessitated by climate change, as well as other water and sanitation investments compelled as a matter of public policy. Among these investments we could include big projects at the head of the systems (catchments, dams), and investments to expand drinking water treatment plants and reservoirs. There is no available information on unit costs by technology type (water treatment plants, wells, filtration galleries, dam construction); additionally, estimating these would require an ad hoc analysis of conditions at the country- or even city-level, thus exceeding the reach of the present study. As a reference, box 1 shows estimates of the investments needed to manage water storage which are a complement to this study.

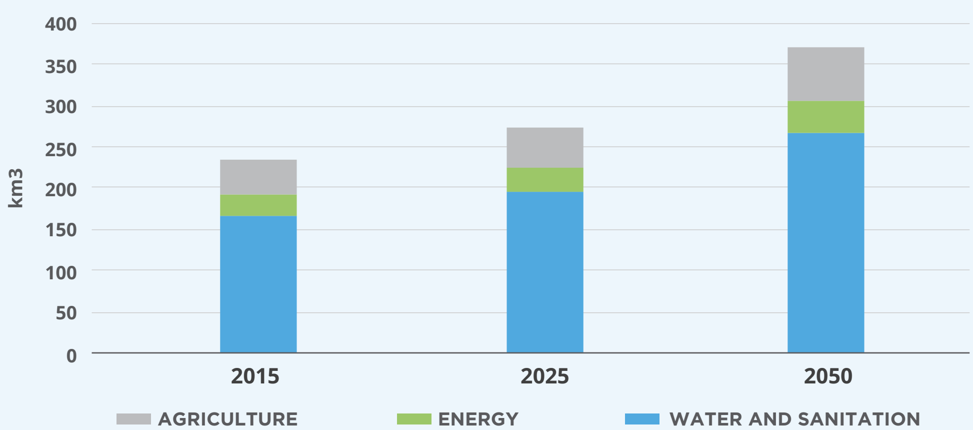
Box 1. Investment needs in water storage infrastructure

To guarantee access to water in adequate quantity and quality, investments in closing the infrastructure gap affecting drinking water requires investments in several levels of the productive process. For example, apart from distribution networks, complementary investments are needed in catchment, storage, and treatment, among others.

Assessments of the drinking water gap in this study includes investments mainly in water distribution networks and household connections. An estimation methodology for complementary investments across LAC is difficult to construct, as the magnitude of these investments rest on factors that differ from country to country, including water treatment technology, production scale, geography, or available water resources. Investments are best estimated on a case-by-case basis.

An IDB document, "A CLEWS Nexus modeling approach" (2019) calculates the infrastructure needs for water storage in LAC. To that end, it estimates current and projected (2015–50) water demand for three uses: agricultural, energy, and water and sanitation services. By 2025, aggregate demand is expected to grow 17 percent over 2015 levels; by 2050 water needs for different uses is expected to increase 59 percent, again, from 2015.

Figure B.1.1. *Projected water demand, by use*



Source: Authors' elaboration based on Muñoz-Castillo, Miralles-Wilhelm, and Machado (2019).

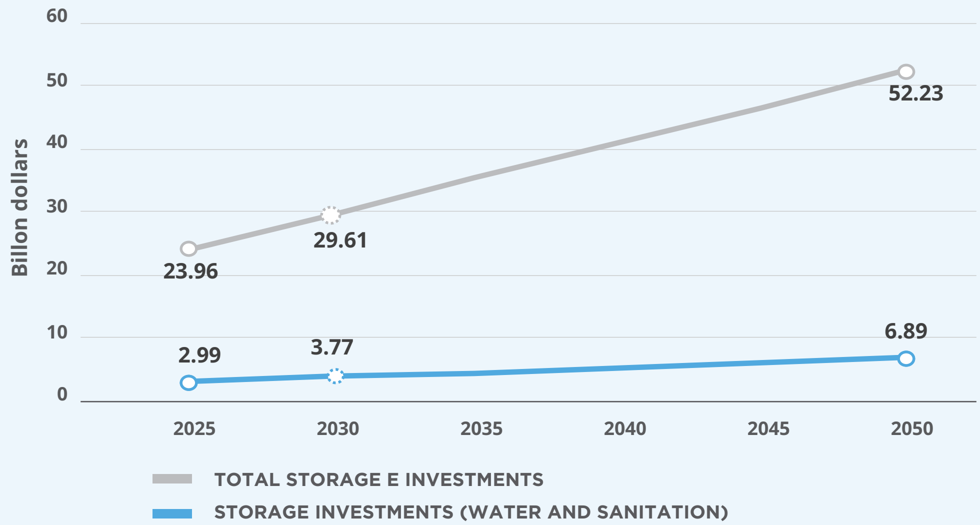
This report estimates investments needed to service growing demand with adequate storage infrastructure. To that end, it uses information on the existing capacity in each country from the AquaStat database, which adds up to a storage capacity in LAC of 1307 km3. This capacity exceeds the region's total aggregate demand, but individual analyses show that by 2025 some countries will face storage capacity deficits.

To calculate the infrastructure gap in storage, the study uses an investment unit cost of USD 1 per cubic meter, which is applied for the countries' deficit in the horizon of this analysis. Thus, the gap would reach USD 23.9 billion by 2025 and USD 52.2 billion by 2050. Assuming a linear progression, investment needs for water storage for agricultural, energy, and drinking water and sanitation uses would reach USD 29.6 billion up to 2030.

Water storage needs for agricultural use are obviously of paramount important for development but go beyond the scope of this estimation of gaps, which focuses on public services. Similarly, and given that our calculation of the electricity gap already includes an analogous component, we opted to exclude the water needs for energy use to avoid double counting.

To estimate the investment gap for storage related to water and sanitation services, we calculate the percentage of water and sanitation demand as a share of total water demand for each country. That percentage is multiplied by the storage capacity to achieve an approximation of each country's storage capacity of water for human consumption. We can thus calculate the investment gap by multiplying the investment unit cost by the storage deficit for human consumption observed in each country. Thus, LAC would need to invest approximately USD 3.8 billion to guarantee storage capacity, which would enable to attend to the increased demand of drinking water and sanitation up to 2030.

Figure B.1.2. *Estimated investment cost needed in water storage infrastructure*



Source: Authors' elaboration, based on Muñoz-Castillo, Miralles-Wilhelm, and Machado, 2019.

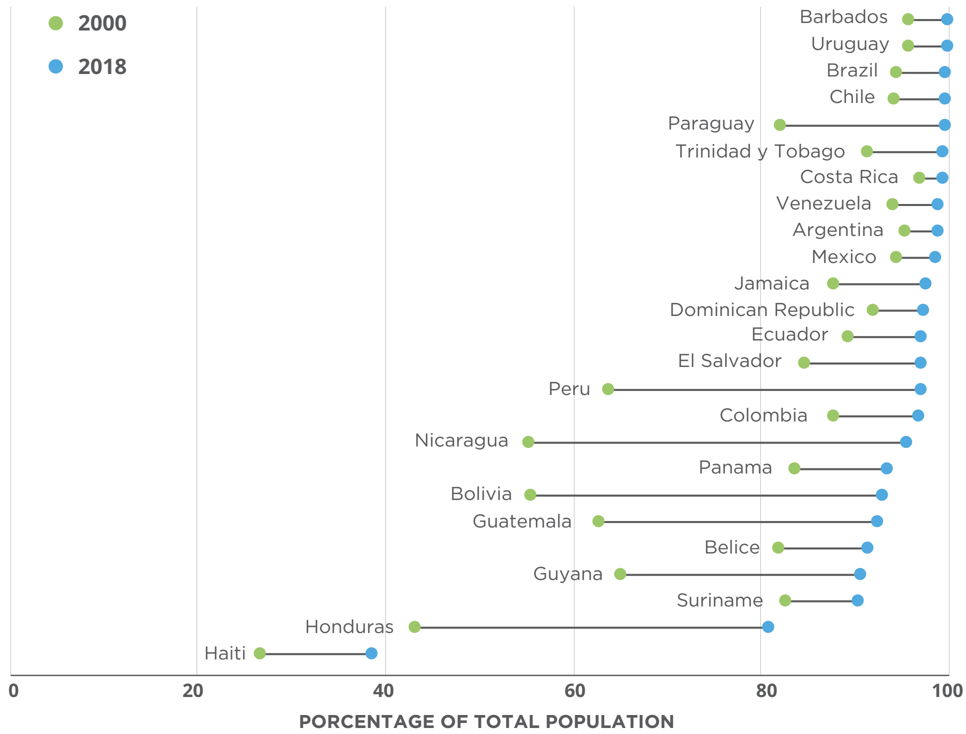
4. REACHING THE SDGs IN ELECTRICITY SERVICES

ANALYZING ELECTRICITY SERVICE IN THE REGION

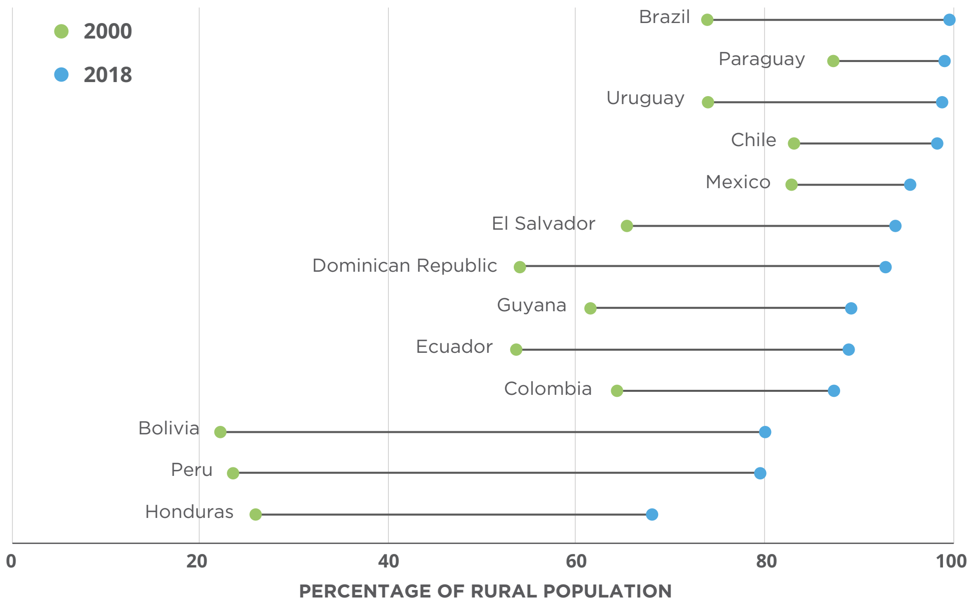
Compared with other developing regions, LAC has taken big strides in electricity service access over the past two decades. LAC beats the global average, and lags only North America, Europe, and Central Asia. But this progress hides enormous heterogeneity both among countries and between rural and urban zones (Castillo *et al.*, 2019). Whereas most of the region's countries have electricity access rates that are higher than 90 percent, in Haiti just 39 percent of the population has an electricity connection. Figure 5 shows the evolution of access to electricity services per LAC country .

Figure 5. *Electricity service in LAC, 2000–18*

PANEL A. EVOLUTION OF NATIONAL ELECTRICITY ACCESS



PANEL B. EVOLUTION OF RURAL ELECTRICITY ACCESS



Source: Cavallo, Powell, and Serebrisky, 2020; Sanin 2019.

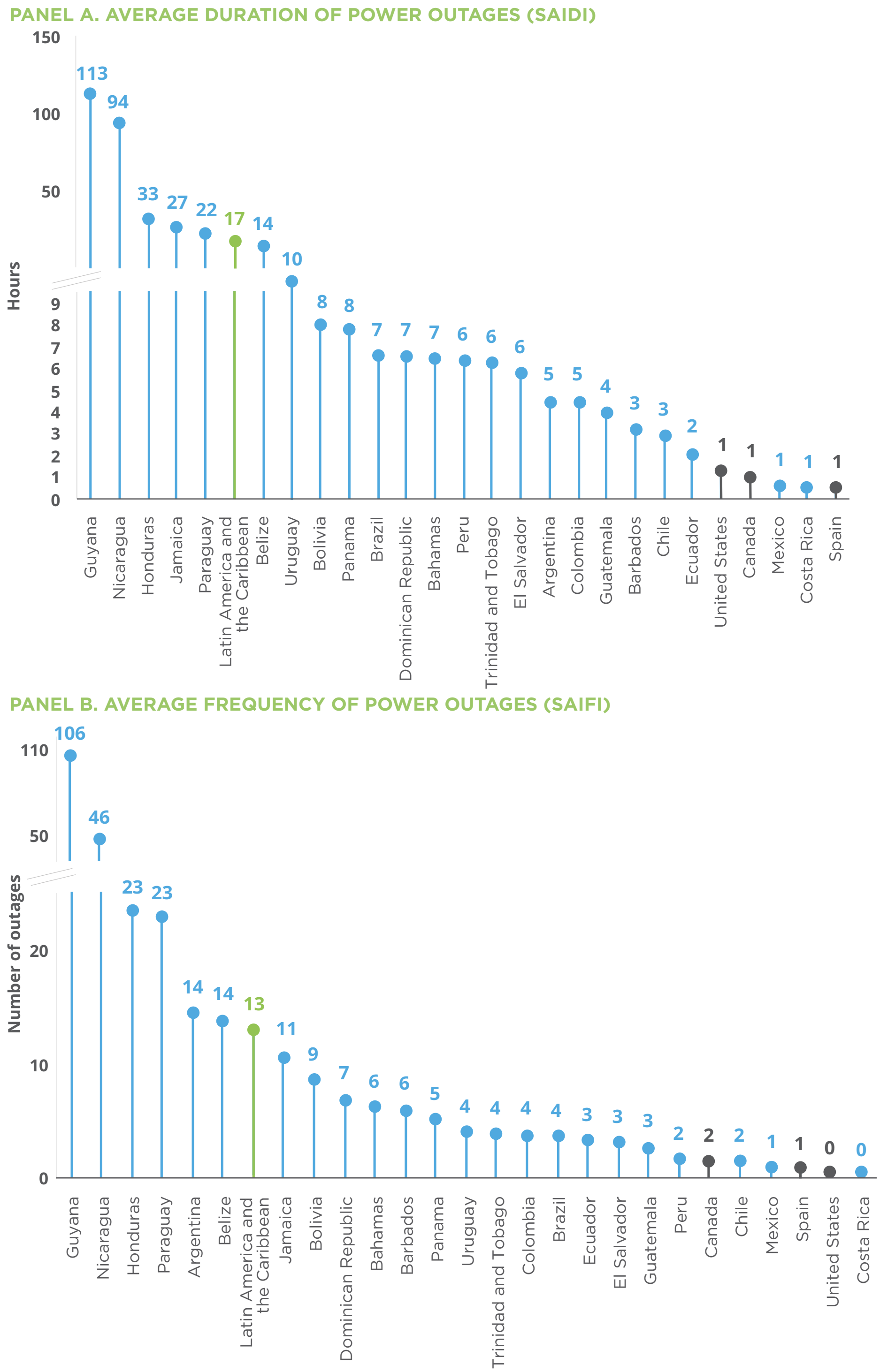
Urban-rural disparities tend to be exacerbated by qualitative aspects. The region has made great progress in expanding coverage in rural areas (Honduras, Bolivia, and Peru are clear cases); but this increase was achieved through decentralized solutions that allow consumption of only a few appliances and which, in many cases, cannot guarantee continuity of service. As universal coverage targets are met, the investments required to reach the "last mile" become costlier and harder to provide, especially if the aim is to provide services with sufficient quality. As it is to be expected, this problem disproportionately affects the lower income populations: in Panama, 47 percent of households in the poorest quintile lack access to electricity; in Guatemala and Honduras more than 30 percent, and in Bolivia and Peru more than 20 percent are in this situation (Iorio and Sanin, 2019).

Apart from the need to achieve universal access to electricity, the region faces multiple challenges related to the improvement of quality of service and to guarantee the sustainable electricity generation. An energy mix based on clean sources, and especially on renewable sources, will reduce contaminating emissions, in keeping with the 2015 Paris Agreement, which aims to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (United Nations, 2015).

Quality issues affecting electricity service are not confined to remote regions or the poor. During 2018, the region had an average of 13 interruptions at an average duration of 17 minutes—high when compared with developed countries. Service disruptions vary widely from country to country (figure 6). Mexico reports quantity and duration of interruptions similar to those of Spain, whereas Honduras reports 23 times more interruptions than Mexico, and their average is 33 times longer. Interruptions mean direct costs to households and businesses, expressed in lost sales, damage to electrical appliances, and even the loss of food due to the interruption of the cold chain.

As far as environmental sustainability is concerned, in the aggregate level, the region has historically had the cleanest electricity generation mix among developing regions. This stems from an intensive use of hydroelectric generation, which is a challenge: the most promising and economic sources of hydroelectricity have already been tapped, which is why keeping the electricity generation mix clean will entail investments in other renewable technologies, such as wind or photovoltaic. Uncertainty is high regarding the costs of meeting that transition to renewable intermittent energies. From a cost standpoint, these sources have recently become more competitive, with a significant cost reduction over the past two decades. At the same time, however, a context in which intermittent renewable energies represent a larger share of the generation mix will require additional investments in the management of the electricity services.

Figure 6. *Average duration and frequency of electricity service interruptions during 2019*



Source: Cavallo, Powell, and Serebrisky, 2020.

Note: SAIDI measures the hours per interruption. SAIFI measures the number of interruptions per year.

Apart from the need to achieve universal access to electricity, the region faces multiple challenges related to the improvement of quality of service and to guarantee the sustainable electricity generation.

/ P. **25**

ESTIMATING THE INFRASTRUCTURE GAP AFFECTING ELECTRICITY SERVICES

Our estimate of the infrastructure gap affecting electricity services has two modules: access to electricity (focused on electricity distribution assets) and the infrastructure gap affecting electricity generation and transmission.

The infrastructure gap affecting access to electricity services

The investment in distribution assets is the first aspect to estimate in assessing the infrastructure gap affecting electricity services and guaranteeing access to all users. The relevant goal is SDG-7, to "Ensure access to affordable, reliable, sustainable and modern energy" by 2030. Target 7.1 seeks by 2030 to "ensure universal access to affordable, reliable and modern energy services". The specific indicator to monitor the progress on this target is the proportion of the population with access to electricity.

For urban and rural access to electricity services, this study uses the existing estimations produced by the IDB's Energy Division. The division's estimates of the investment gaps for the achievement of universal residential access to electricity in LAC are available at the Energy Hub[16]. These estimates used the coverage indicators available in the OLADE report (see Castillo *et al.* 2019),complemented with information from household surveys and verified by IDB experts and energy ministries around the region. The study also reports the unit costs of the different applicable solutions to provide access to electricity services, from network connection in urban environments to various decentralized solutions for rural areas, where population density does not merit setting distribution networks[17].

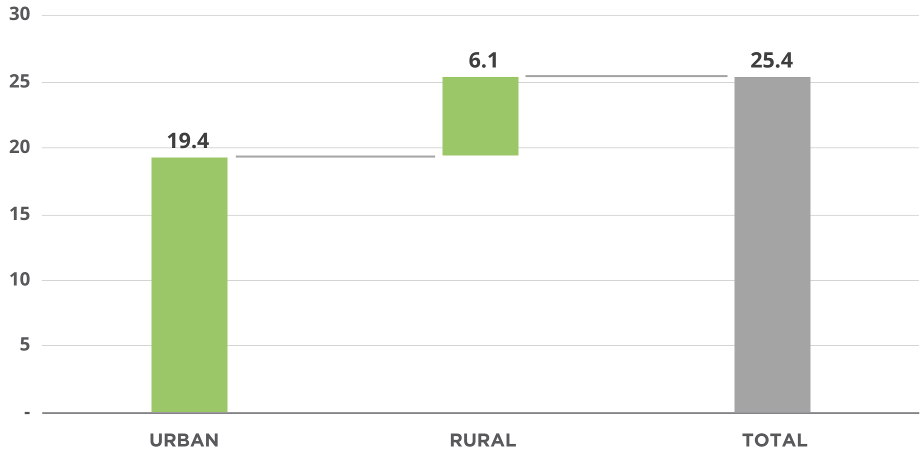
According to our calculations, the region will need to invest USD 25.4 billion in new infrastructure to guarantee universal access to electricity services by 2030. Approximately 80 percent of those investments would be in urban areas. Rural access rates to electricity services are lower, but the absolute number of urban residents without access to services is higher. Additionally, population projections and migration trends will increase the number of urban users over the next decade.

16 The estimations for the "Investment gap for universal access to electricity by 2030" are available at: https://hubenergia.org/en/indicators/investment-gap-universal-access-electricity-2030. Last accessed in August 2021.

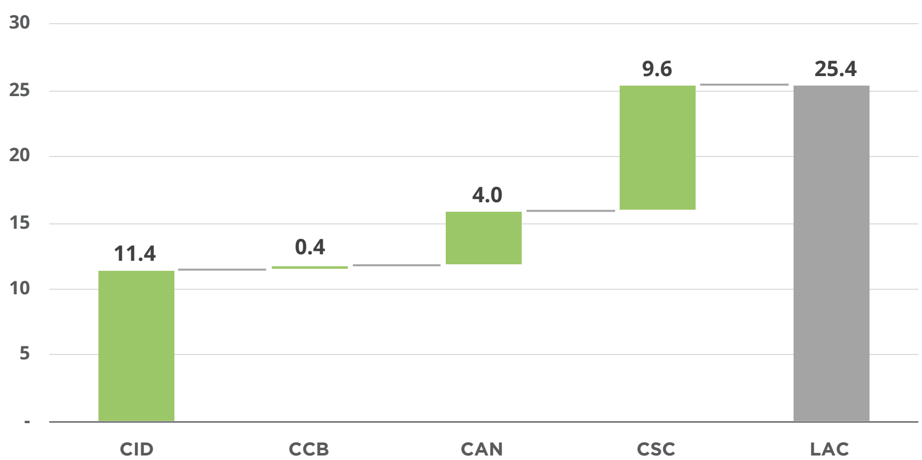
17 For more details on the calculation methodology, see the Annex and the methodological document of the estimation of the investment gap to achieve universal residential access to electricity in LAC.

Figure 7. *Total investments needed in new infrastructure through 2030 to ensure access to electricity services (USD billions)*

URBAN-RURAL



BY REGION



Source: Authors' elaboration.

Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay.

Just as with water and sanitation services, LAC will need to make additional investments to maintain existing distribution assets and to replace those that reach the end of their lifespan. These additional investments (the assumptions are detailed in the Annex) amount to USD 64.1 billion. Consequently, the total investment gap would be USD 89.5 billion, which entails an annual average investment of about 0.13 percent of regional GDP. Table 7 details the investment needs estimated for each of the countries of the region.

Table 7. *Total investments needed by 2030 to close the infrastructure gap affecting access to electricity, by country total (in USD millions)*

COUNTRY	INVESTMENT NEEDS		
	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	674	4,068	**4,743**
Barbados	35	39	**74**
Belize	27	32	**59**
Bolivia	776	1,222	**1,998**
Brazil	8,301	24,326	**32,627**
Chile	310	1,903	**2,213**
Colombia	1,239	5,026	**6,265**
Costa Rica	168	540	**708**
Ecuador	624	1,576	**2,200**
El Salvador	433	693	**1,126**
Guatemala	1,425	1,534	**2,959**
Guyana	99	90	**190**
Haiti	4,876	1,705	**6,580**
Honduras	833	800	**1,633**
Jamaica	170	320	**490**
Mexico	2,551	11,569	**14,120**
Nicaragua	263	433	**696**
Panama	480	487	**967**
Paraguay	277	659	**936**
Peru	734	2,940	**3,674**
Dominican Republic	384	1,094	**1,478**
Suriname	93	69	**162**
Trinidad & Tobago	11	112	**123**
Uruguay	23	394	**417**
Venezuela	615	2,486	**3,101**
Total	**25,420**	**64,118**	**89,538**
Annual investment (% of GDP)	**0.04%**	**0.09%**	**0.13%**

Source: Authors' elaboration.

Note: see the Annex for details of countries without available information.

The infrastructure gap affecting electricity generation and transmission

Electricity services require more than connecting all households. To produce and transmit energy, countries must have power generation plants and transmission lines. The electricity sector is peculiar: it allows no lapse in time from production to consumption. The energy demanded must equal the energy supplied in infinitesimal intervals, just like that, or the system collapses. This means that planned investments need to incorporate margins in generation and transmission that guarantee energy security for households and businesses across the region. This is particularly challenging, as intermittent renewable generation technologies (solar, wind) become more important players in the electricity mix. In this regard, SDG-7 includes two relevant targets: target 7.1, discussed in the previous section, and target 7.2: "to increase substantially the share of renewable energy in the global energy mix."

Unlike the previous module (universal coverage for electricity service), the SDGs provide no clear goal. On the contrary, an increase in renewable sources participation can be achieved in several ways, and each country has intrinsic characteristics regarding availability of resources and energy sources. Still, with the challenge posed by decarbonization, the investments and efforts to attain target 7.2 will proceed largely from making renewable sources a larger share of the electricity generation mix, while shifting generation assets toward resilient, efficient, and sustainable infrastructure. The penetration of these technologies in the region will depend on the availability of natural resources (natural gas, oil, coal) and their direct competition with new technologies as global costs decline, as well as on market structures and other regulatory conditions.

For this study we decided to use the investment patterns presented by IDB specialists (Yepez-Garcia, Hallack, Ji, and Lopez Soto, 2019) and recent updates (Yepez-Garcia, Hallack, Mejdalani, and Lopez Soto, 2021). Building from the electricity generation expansion plans of LAC countries and on assessments of demand, this paper estimates the investment needs required for the 2020–30 period both to expand generation capacity and to replace obsolescent generation plants. The resulting generation mix for LAC guarantees provision of expected electricity demand while incorporating more emission-free sources in generation. In these estimates, wind and photovoltaic technologies rise from 7.9 percent of LAC's electricity mix in 2019 to 17.1 percent in 2030; and generation from emission-free sources increases from 63.4 percent to 70.4 percent. Note that generation from wind and solar technologies grows at a 9.6 percent accumulated annual rate (compared to a 2.3 percent growth in demand), which aligns with SDG language that countries "increase substantially the share of renewable energy in the global energy mix."[18]

18 The Annex includes the sources of information we used, the calculation methodology for the estimation of electricity demand in the period, and the calculation methodology for the estimations of the investment needs.

Planned investments need to incorporate margins in generation and transmission that guarantee energy security for households and businesses across the region. This is particularly challenging, as intermittent renewable generation technologies (solar, wind) become more important players in the electricity mix.
/ P. **32**

As a result, the region would need to invest USD 371.5 billion in new infrastructure for electricity generation and transmission networks by 2030. Additionally, the costs of replacing obsolete assets rise to USD 116.1 billion through 2030, making the total investments to attain targets under SDG-7 USD 487.5 billion (or annual investment needs of 0.69 percent of regional GDP). Table 8 summarizes the investment needs expected for LAC and each country in the region.

Table 8. *Total investments needed to close the electricity generation and transmission gap by 2030, by country (in USD billions)*

COUNTRY	INVESTMENT NEEDS		
	NEW INFRASTRUCTURE	ASSET REPLACEMENT	TOTAL
Argentina	52.3	22.5	**74.8**
Belize	1.1	0.1	**1.2**
Bolivia	4.0	1.1	**5.1**
Brazil	108.1	49.2	**157.3**
Chile	30.2	18.0	**48.3**
Colombia	25.7	9.1	**34.8**
Costa Rica	2.6	1.9	**4.5**
Ecuador	18.8	2.2	**21.0**
El Salvador	4.9	0.9	**5.8**
Guatemala	4.4	1.8	**6.3**
Guyana	0.5	0.0	**0.5**
Haiti	0.1	0.1	**0.2**
Honduras	3.2	0.5	**3.8**
Jamaica	0.8	0.9	**1.7**
Mexico	81.8	3.1	**85.0**
Nicaragua	1.6	0.6	**2.2**
Panama	4.4	0.3	**4.7**
Paraguay	2.9	0.2	**3.1**
Peru	12.6	1.1	**13.7**
Dominican Republic	6.9	0.3	**7.1**
Suriname	0.0	0.1	**0.1**
Trinidad & Tobago	0.7	0.7	**1.3**
Uruguay	3.8	1.3	**5.1**
Total	**371.5**	**116.1**	**487.5**
Annual investment (% of GDP)	**0.52%**	**0.16%**	**0.69%**

Source: Authors' elaboration.
Note: see the Annex for details of countries without available information.

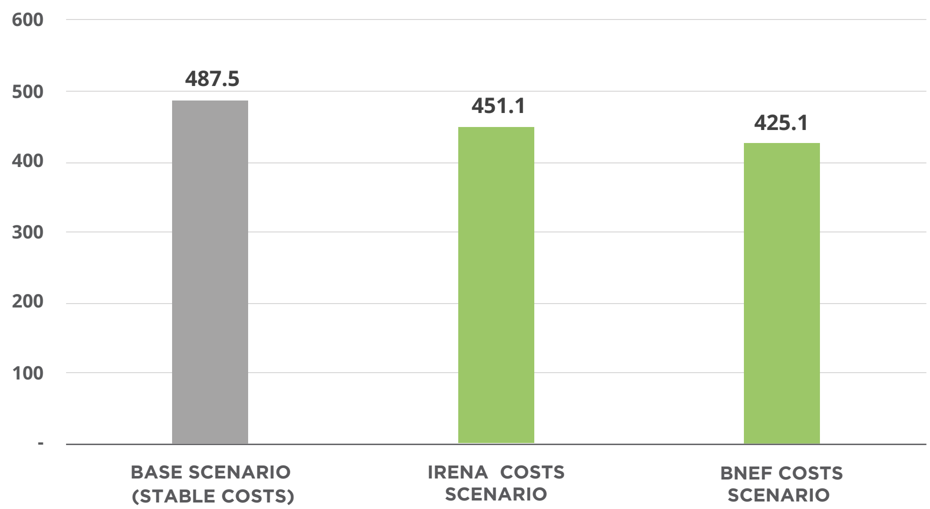
Note that these estimates rest on uncertain assumptions, such as how renewable technologies will evolve over time.

First, the quantified expansion of renewable generation is in line with capacity expansion plans reported by LAC countries. These plans are usually reevaluated so keep pace with the countries' nationally determined contributions (NDCs), keeping their ambitions in line with the goals of the Paris Agreement. This suggests that the countries might incorporate a higher-than-planned proportion of renewable sources to meet more ambitious commitments. Increasing shares of renewable energies generally has impacts not only on generation investments but also in the complementary investments needed to manage a network that can guarantee energy security given the intermittency of these new generation sources. Accordingly, when, in this estimate, the emissions in the electricity generation subsector drop by 23 percent (per generated MWh), these investments will become a lower bound for climate change mitigation. This is because this scenario might deviate from the deep-decarbonization seen necessary for economies, consistent with the Paris Agreement: "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels…."

Second, the estimation of investment needs uses the current generation costs of each of the available technologies according to data reported by the National Renewable Energy Agency (NREL) of the United States Government. But the past decade has seen a sustained trend of falling generation costs, especially in solar and wind technologies, a trend the extends to LAC. In 2019, tenders in the region awarded solar energy contracts in Mexico, Peru, and Chile, and wind energy contracts in Mexico, at a price of USD 30 per MWh—among the lowest prices globally (IEA, 2019).

Falling prices in renewable generation could result in notable cutbacks in investment needs. For example, using the declining cost trend of the past five years reported by the Renewable Energy Agency (IRENA) and projecting it toward 2030, total investment needs fall to about USD 451 billion. With the costs for unconventional renewable generation projected by Bloomberg New Energy Finance (BNEF), the drop would be even greater, to about USD 425 billion. This implies declines of up to 13 percent of the total investment expected in the baseline scenario.

Figure 8. *Impact of the falling costs of unconventional renewable sources (solar, wind, geothermal) on electricity generation investment needs (in USD billions)*



Source: Authors' elaboration.

Final comments on bridging the gap affecting electricity services

The estimates pertaining to the two modules we defined for the calculation of the infrastructure gap in the electricity sector show that, to guarantee universal and sustainable access in line with the infrastructure targets of SDG-7, LAC will have to implement total investments of USD 577.1 billion. From that total, USD 396.9 billion should go toward building new generation, transmission, and distribution infrastructure. Additionally, maintenance costs for existing networks and the replacement of obsolescent assets in transmission and distribution rise to USD 180.2 billion. Therefore, achieving the targets associated with SDG-7 infrastructure needs will require a regional annual investment of at least 0.8 percent of GDP by 2030.

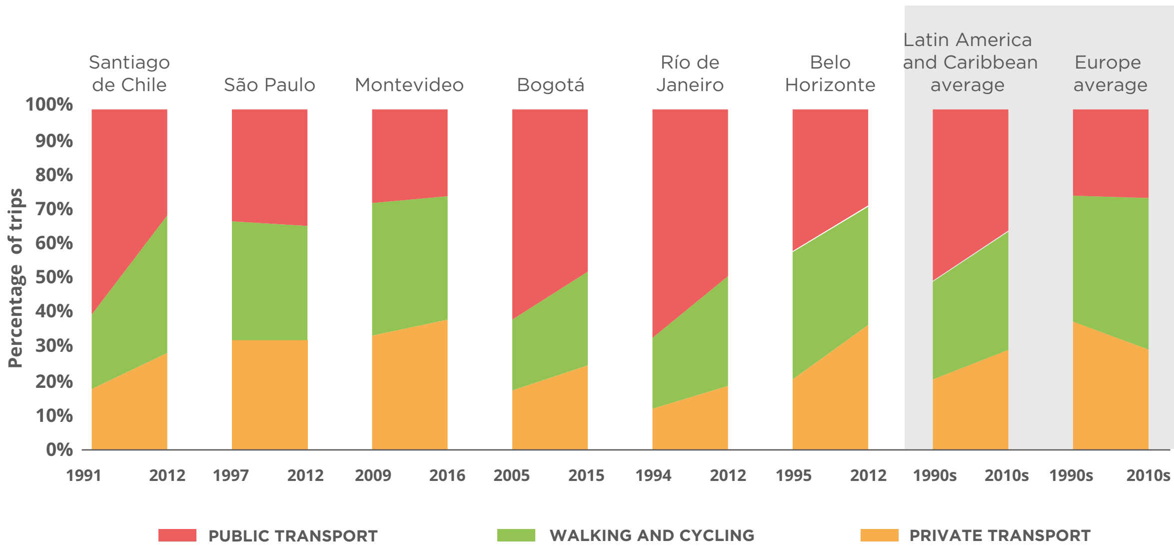
5. REACHING THE SDGs IN TRANSPORTATION

ANALYZING TRANSPORTATION SERVICES IN THE REGION

Transportation services affect economic growth and development through several channels. Logistics, for example, has a direct impact on costs and the ability of businesses to export goods in an efficient manner. Logistics help economies integrate into regional and global value chains. Inadequate urban public transportation limits residents' access to jobs and health services, hindering both productivity and equity.

Regarding urban transport, the region has seen scant progress in recent years. A 10-city survey conducted by the Development Bank of Latin America (CAF) found almost-universal access to public-transportation stops in a three-block household radius—from 87 percent in Bogota, 90 percent in Panama and Quito, to 98 percent in Buenos Aires and Montevideo. Yet these benefits diminished by low marks for frequency, safety, and reliability. Yes, the region has public transportation stops, and in many cases adequate city roads, but again service quality is deficient, limiting residents' access to workplaces, schools, and health-care providers. Consequently, users will solve their transportation needs with private transportation; figure 9 shows travel modes for several LAC cities

Figure 9. *Use of three transportation modes in selected cities*



Source: Cavallo, Powell, and Serebrisky, 2020.

Note: Comparisons among cities are limited by differences in methodologies and timing of surveys. Private transport includes cars and motorcycles. Cities included in the European average are Amsterdam, Berlin, Copenhagen, Hamburg, London, Munich, Paris, Stockholm, Vienna, and Zurich.

The effect of unreliable public transport is corroborated by a study of three of the region's largest cities—Ciudad de Mexico, Bogota, and Santiago de Chile. It found that private transportation for workplace commutes of under 60 minutes is much higher than commutes by public transportation (ITF, 2020); travel time accounts for rush-hour congestion and the time to find a parking spot.

Additionally, unplanned urban growth has strained transportation networks. As cities expand to accommodate a growing population, core-city density declines. With fewer walkable neighborhoods close to the main thoroughfares and limited public transport between urban centers and their peripheries, walking in peri-urban zones becomes harder. Longer walking distances and inadequate pedestrian infrastructure detract from work and daily life (Rivas, Suárez-Alemán, and Serebrisky, 2019).

These trends have evident consequences. Compared with people living in the most advanced economies, commuters in LAC need more time for even short trips. Average travel time to and from work in LAC cities is 77 minutes; in advanced economies travel time is two kilometers farther but takes 65 minutes (Rivas, Suárez-Alemán, and Serebrisky, 2019). In many cities, from the more populous such as Bogota (Colombia) to less populated ones such as Manaus (Brazil), and from established mega-cities such as São Paulo (Brazil) to rapidly expanding urban areas such as Lima (Peru), the average commute can last more than 90 minutes. According to Moovit's 2019 Public Transport Index, in several cities such as Monterrey, Mexico City, Bogota, and San Jose, at least 25 percent of people make average commutes (one way) of between 1 and 2 hours.

The scenario is not much better regarding sector logistics. The latest Logistics Performance Index (World Bank, 2018) places the region barely at 2.66 in general performance for public transport, well behind Europe (3.40) and East Asia and the Pacific (3.13). It approaches scores seen only in the Middle East and North of Africa (2.78). At the same time, the region fell below its 2014 score, when it scored 2.79. The region had scores like those for South Asia and Sub-Saharan Africa across all components of the index; transportation infrastructure quality and customs efficiency both had worse relative scores (Calatayud and Montes, 2021).

The countries of LAC could reap significant benefits by improving their logistics performances. Among other impacts, logistics failures determine market access and so affect trade costs. Calatayud and Montes (2021) estimate that improving the region's quality of logistic services by one unit (taking it to levels comparable to those seen in European countries), LAC exports would increase by around 7 percent. The increase would be 5 percent with improvements of the same magnitude in transportation infrastructure quality. Benefits could be even higher when considering exports by economic sector. With improvements of one unit in the quality of logistics-services, exports of manufactured goods would rise 18 percent, increasing 12 percent with the same increment of improvement in transportation infrastructure. For goods that are highly technology-intensive, a one-unit increase in the quality of logistics services would increase exports by 25 percent and imports by 17. Similarly, a 17 percent increase would occur with improved transportation infrastructure by the exporting country. Additionally, progress in logistics would allow LAC countries to take advantage of reconfigured global value chains. Large corporations and consumer markets are attempting to diversify their supply organizations to bring more resilience and better risk management in the face of eventual shocks, like those seen with the COVID-19 pandemic.

ESTIMATING THE INFRASTRUCTURE GAP AFFECTING TRANSPORTATION SERVICES

The infrastructure gap for transportation services is estimated here in three modules: access to road infrastructure, investment needs linked to logistics investments for airports, and the infrastructure gap in urban mass transit.

Average travel time to and from work in Latin America and the Caribbean cities is 77 minutes; in advanced economies travel time is two kilometers farther but takes 65 minutes.

/ P. **38**

The infrastructure gap affecting rural access to the road network

The first module to estimate the infrastructure gap in transportation services is linked to road infrastructure so rural populations have guaranteed access. The relevant SDG is SDG-9, to "Build resilient infrastructure, promote sustainable industrialization and foster innovation." Target 9.1 is more specific: "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all." The key indicator for this target, 9.1.1, is the proportion of rural households with access in a 2-km radius to a transitable road year-round through all seasons, as measured by the Rural Accessibility Index (RAI).

Although indicator 9.1.1 has no set access level, the target suggests the need for universal rural access to a road network under the standards set by the indicator. Given the "by 2030" temporal framework of this study, this is an unrealistic goal.

Scant physical and demographic information makes it difficult to calculate the indicator. In an ideal scenario, researchers could superimpose highly granular maps of population density over geo-localized maps of road networks—maps that include qualitative features. But without these tools and databases, it would be impossible to map which road networks are transitable year-round.

This limitation is not confined to LAC. The World Bank (2019b) is therefore helming efforts to measure rural accessibility across a broad swath of countries. Peru is the only country in LAC now swept up in this effort. But measurements for this country will provide valuable information. Using algorithms to measure the optimal expansions, the World Bank determined the most efficient ways (paved networks, gravel, etc.) of achieving the RAI targets (Mikou *et al*., 2019). From that exercise, we derive two relevant conclusions.

1. The costs of building road infrastructure to reach remote and dispersed populations increase exponentially with RAI values. In other words, universal rural access is not a viable goal. Alternative solutions need to be devised.

2. The economic costs linked to the construction and maintenance of road networks that seek to increase the RAI coverage require considering low-cost alternatives (for example, gravel solutions), to find the more cost-effective ones.

The World Bank provides a useful theoretical exercise for this study. It calculated RAI across a sample of 110 countries and their road networks. Although geo-localized, the sample lacked information on year-round transitability. Nevertheless, four road-access scenarios emerged:

1. primary networks;
2. primary and secondary networks;
3. primary, secondary, and tertiary networks; and
4. primary, secondary, and tertiary networks, and local roads.

This exercise found that, for those countries with effective RAI measurements, the results replicated reasonably well under scenario 2.

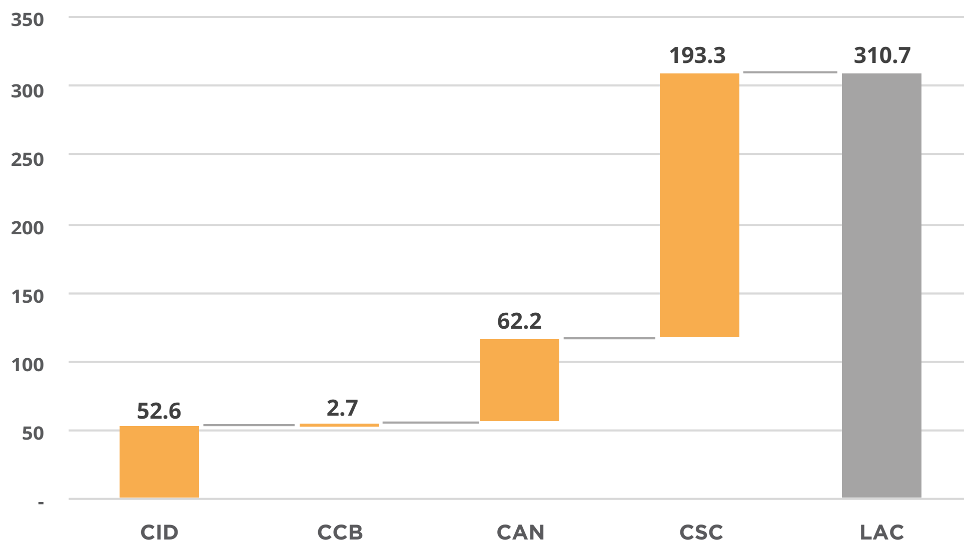
In considering only primary and secondary roads, this exercise found the RAI for LAC is 35 percentage points. By extending the calculation to scenario 3, with its tertiary roads, the indicator rises to 70 percentage points. So guaranteeing a year-round, transitable tertiary network could double rural access to road networks as defined by the RAI. Consequently, the "by 2030" goal of expanding rural access to the road network can be attained with the existing tertiary network transitable year-round and increasing coverage in line with its historical expansion.

To make these estimates, we used information on road length in kilometers, road type, and transitability all provided by the International Road Federation. These data were validated, updated, and expanded by specialists in the IDB's Transport Division. Having established the coverage and quality of the road network, we proceeded to calculate investments needed to guarantee transitability and increase capacity in line with the expected demand for the primary, secondary, and tertiary road networks using construction and maintenance costs reported by the World Bank's Road Costs Knowledge System (ROCKS) database[19].

We found that to guarantee transitability and increase capacity, the region will need to invest around USD 310.7 billion by 2030.

19 The Annex includes the sources of information we used and the calculation methodology to estimate investment needs.

Figure 10. *Total investments needed in new road infrastructure through 2030 to ensure better access to transportation services in rural areas (by region, USD billion)*



Source: Authors' elaboration.

Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay.

We have also calculated the investments needed to maintain existing assets and replace assets that will become obsolete by 2030. These additional expenditures amount to USD 427.8 billion. Consequently, to close the rural-access gap to roads and attain SDG-9—as we understand it in this study—total investments by 2030 would be USD 738.5 billion, or annual investment needs of about 1.04 percent of regional GDP. Table 9 details the region's overall investment needs and those of each LAC country.

Table 9. *Total investments needed to close the road infrastructure gap affecting transportation services in rural environments (USD billion)*

COUNTRY	INVESTMENT NEEDS		
	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	25.7	41.7	**67.4**
Bolivia	14.4	14.1	**28.5**
Brazil	154.5	179.0	**333.5**
Chile	8.7	13.8	**22.5**
Colombia	21.5	32.1	**53.6**
Costa Rica	4.6	6.5	**11.0**
Ecuador	9.9	13.3	**23.2**
Guatemala	1.9	3.4	**5.3**
Honduras	1.6	2.2	**3.8**
Jamaica	2.3	3.5	**5.8**
Mexico	38.0	81.4	**119.4**
Nicaragua	2.4	2.9	**5.3**
Panama	1.8	3.3	**5.1**
Paraguay	3.4	4.9	**8.3**
Peru	16.3	19.5	**35.8**
Dominican Republic	2.2	4.1	**6.4**
Suriname	0.4	0.4	**0.7**
Uruguay	1.0	1.8	**2.8**
Total	**310.7**	**427.8**	**738.5**
Annual investment (% of GDP)	**0.44%**	**0.60%**	**1.04%**

Source: Authors' elaboration.

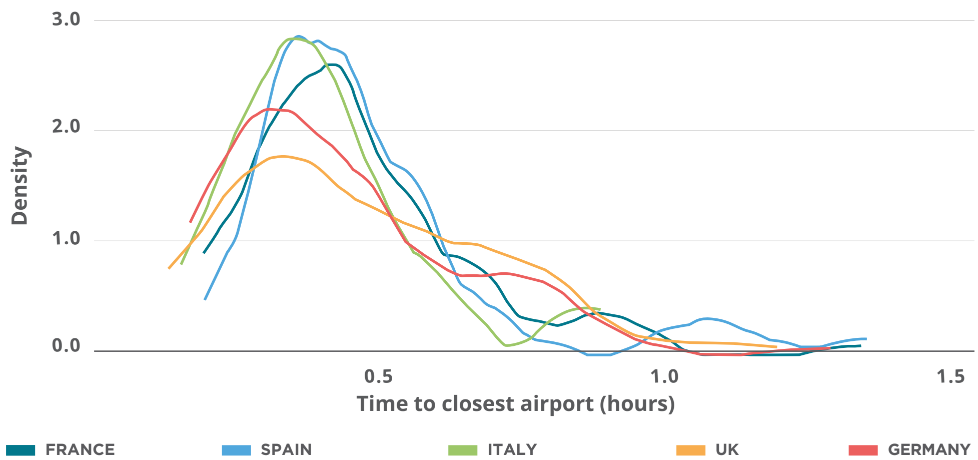
Note: See the Annex for details of countries without available information.

The infrastructure gap affecting airports

A key indicator for measuring logistics infrastructure and attaining SDG-9 is the volume of passengers and freight transported by each transport mode (indicator 9.1.2). In this case, the SDG does not provide a clear target; the airport infrastructure gap estimated in this report was informed with reference to the CAF assessments of the port gap. These investments would help to close the logistics gap.

We first estimated the airport infrastructure gap to guarantee access to air transportation based on the information presented by Brichetti et al. (2021). That paper estimated investments that would guarantee access to airport infrastructure for cities with 100,000-plus inhabitants; a spatial exercise determined urban populations in LAC lacking access to an airport less than one hour away. These accessibility criteria were set by comparing travel times in countries with highly developed air markets (western Europe and the United States, figure 11).

Figure 11. *Time distributions of trips to the closest airport from urban centers of at least 100,000 inhabitants, by country*



Source: Brichetti et al. (2021).

By 2030, according to this analysis, the region will have to invest USD 15.2 billion in new airport infrastructure to guarantee access to all urban centers with 100,000-plus inhabitants. This translates into annual investment needs of about 0.02 percent of regional GDP. Table 10 summarizes LAC's estimated investment needs and breaks these down for every country in the region.

Table 10. *New airports for urban centers with 100,000-plus inhabitants: Total investment by 2030 (by airport size, in USD millions)*

PAÍS	INVESTMENT NEEDS				
	VERY LARGE AIRPORTS	LARGE AIRPORTS	MEDIUM AIRPORTS	SMALL AIRPORTS	TOTAL
Argentina	-	-	-	420	**420**
Bolivia	-	-	-	70	**70**
Brazil	1,200	1,200	750	1,260	**4,410**
Chile	-	300	300	70	**670**
Colombia	-	-	300	210	**510**
Ecuador	-	300	-	70	**370**
El Salvador	600	-	-	-	**600**
Guatemala	-	-	-	210	**210**
Haiti	-	-	150	70	**220**
Honduras	-	-	-	140	**140**
Mexico	1,800	900	450	910	**4,060**
Nicaragua	600	-	-	-	**600**
Panama	-	-	-	70	**70**
Paraguay	-	-	-	140	**140**
Peru	-	-	450	280	**730**
Dominican Republic	-	-	-	70	**70**
Suriname	-	-	-	70	**70**
Venezuela	600	300	450	490	**1,840**
Total	**4,800**	**3,000**	**2,850**	**4,550**	**15,200**
Annual investment (% of GDP)					**0.02%**

Source: Authors' elaboration.

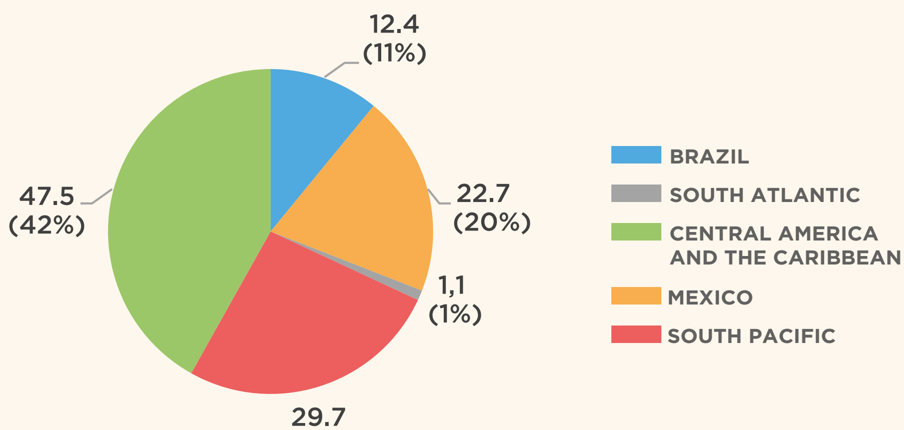
Note: "Very large" airports serve more than a million inhabitants; large airports, 500,000 to 1 million; medium airports, 300,000 to 500,000; and small airports, between 100,000 and 300,000. The Annex has information on countries without available information.

The assessments show that the investment figures respond both to travel times and population thresholds. Travel times ensure cities are adequately served, while minimum thresholds justify the investment. Setting looser criteria for the exercise (e.g., two-hour travel times, 200,000-plus inhabitants) trim up to 65 percent off the investments. This is relevant: this study's objective is to give orders of magnitude for the investments. But more detailed country analyses may better determine what airport investments are best. International experience shows that over-investment in airports (i.e. too many facilities being built too close together) has led to underutilization due to low demand, as in the case of some airports in Spain.

Box 2. Investment needs in port infrastructure

Adequate port infrastructure guarantees the maritime transportation of goods. Many countries are expected to surpass the saturation level recommended for ports; closing the gap in port infrastructure therefore requires urgent attention. According to the Development Bank of Latin America (CAF, 2016), by 2040 the difference between demand and container-handling capacity in LAC ports will reach a total of 113 million twenty-foot equivalent units. Central America and the Caribbean account for 42 percent of this gap, followed by the South Pacific (26 percent) and Mexico (20 percent).

Figure B.2.1. *Port gap by LAC subregion by 2040 (millions of twenty-foot equivalent units)*



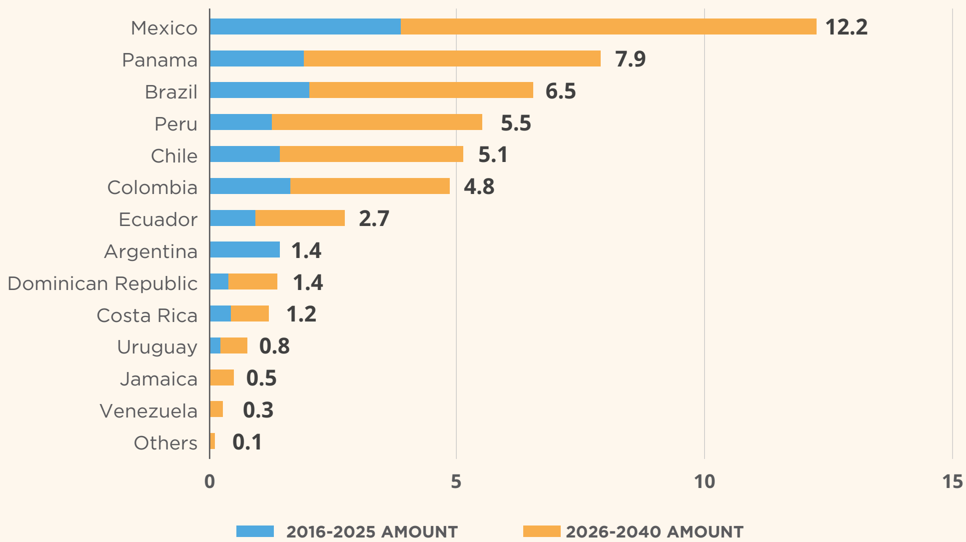
Source: Authors' elaboration based on CAF (2016).

Note: The figure uses CAF's regional classifications. South Atlantic: Argentina, Uruguay, Paraguay. South Pacific: Chile, Bolivia, Peru, Ecuador, Colombia. Pacific, Central America and the Caribbean: Caribbean Colombia, Venezuela, Panama, Costa Rica, Dominican Republic, Jamaica, Barbados, Trinidad & Tobago, and other Central American and Caribbean countries that are not CAF members.

According to CAF's (2016) estimates, closing the port infrastructure gap by 2030 to meet the expected demand would require investments of approximately USD 50 billion. This amount includes both the increase in the capacity needed for container manipulation in the face of increasing demand, and activities such as deeper dredging in port nodes.

As figure B.5.1.2 shows, below, 30 percent of the total amount are investments needed in the port sector up to 2025. The list is topped by Mexico (with USD 12.2 billion needed in investments until 2050 and USD 3.9 billion to 2025), followed by Panama (USD 7.9 billion to 2040 and USD 1.9 billion to 2025), and Brazil (USD 6.5 billion to 2040 and USD 1.9 billion to 2025).

Figure B.2.2. *Estimated investment in new container port infrastructure, 2016–40 (USD billions)*



Source: Authors' elaboration based on CAF (2016).

Mobility demands can be met in many ways, and optimal choices often rest on network effects.

/ P. **52**

The infrastructure gap affecting urban mass transit

Massive urban transportation projects pose investment gaps that are difficult to measure. The efficacy and efficiency of these systems depend on urban density, morphology, and geography; they depend on localized nodes for jobs, education, and health care. Additionally, mobility demands can be met in many ways, and optimal choices often rest on network effects. With these difficulties in mind, SDG-11 stipulates the need by 2030 to "provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" (target 11.2). The target indicator (11.2.1) mentions a proportion of the population having convenient access to public transportation by gender, age, and disability. But it establishes no quantitative targets. To produce a viable calculation, this study therefore defines the urban mobility infrastructure gap (SDG-11) with a benchmarking exercise that compares the region's "best-performing" cities with those having 500,000-plus inhabitants[20].

For this exercise, we gathered design information on mass transportation in LAC and in OECD countries, including Bus Rapid Transit (BRT), urban railroad, and subway systems. To determine the unit costs per kilometer for each of these systems, we used the average values of relevant projects in the region and worldwide over the past two decades, as identified by the IDB's Transport Division. Finally, we considered scenarios with various infrastructure combinations to guarantee urban mobility in the region[21].

For cities to attain the coverage of the region's best-performing urban centers—in a cost-effective scenario based on BRT—we found that for each city with 500,000-plus inhabitants, the region will need to invest at least USD 222.4 billion in new urban-mobility infrastructure by 2030[22]. This figure translates into annual investments of 0.31 percent of regional GDP. These estimates leap when OECD cities are a benchmark or when urban-mobility deficits are solved with rail.

---

20 As a performance indicator, we use the total kilometers of mass public transport (BRT and rail) per million inhabitants. For cities with over 5 million inhabitants, we selected three cities with the highest values for this indicator: Buenos Aires, Rio de Janeiro, and Santiago. For cities having between 500,000 and 5 million inhabitants, three Brazilian cities have the highest values for this indicator (Natal, Porto Alegre, and Recife); we therefore included a fourth city (Cordoba, Argentina) so the best performing cases were more representative of the region. The Annex provides further details.

21 The Annex includes the sources of information we used and the calculation methodology to estimate investment needs.

22 The scenario plans more kilometers for massive urban transportation and in this way attain the coverage per-million-inhabitants of the benchmark set by the best-performing Latin American cities: 75 percent using BRT, 15 percent urban rail, and 10 percent underground systems.

Table 11. *Total investments needed in mass transportation infrastructure through 2030 (cost-effective solution based mainly in BRT, USD billions)*

COUNTRY	INVESTMENT NEEDS (NEW INFRASTRUCTURE)
Argentina	5.8
Bolivia	2.2
Brazil	80.4
Chile	2.1
Colombia	25.7
Costa Rica	3.6
Ecuador	5.3
El Salvador	3.4
Guatemala	4.1
Haiti	1.2
Honduras	1.0
Jamaica	0.3
Mexico	51.2
Nicaragua	0.5
Panama	1.5
Paraguay	1.5
Peru	15.1
Dominican Republic	4.5
Trinidad & Tobago	0.2
Uruguay	2.1
Venezuela	10.6
Total	**222.4**
Annual investment (% of GDP)	**0.31%**

Source: Authors' elaboration.

Note that SDG-11 demands environmentally sustainable solutions. Since the base scenario relies on automotive transport solutions, electromobility (electric cars and buses) will play a vital role. Box 3 presents investments that would start to convert mass transport to more sustainable systems based on electromobility.

Box 3. Cost of electromobility for urban mass transport in LAC

The emissions commitments under the 2015 Paris Agreement make sustainable transportation a key issue. Urban mass transportation plays a vital role in lowering emissions from private transportation emissions, reducing total emissions and contaminant particles in urban environments, where their health effects are worse.

Environmentally sustainable urban mass transportation systems do not stop at curtailing emissions from private transport: public transportations systems must themselves curb emissions. Historically, the emissions of the buses used to provide urban mass public transportation have been a significant source of air contamination, because they used contaminating fossil fuels. The advancement of environmental standards for internal combustion engines has, in relative terms, improved the situation but is not the solution. Electromobility is key for medium-term, environmentally efficient solutions, bearing in mind that resort to clean energy sources is expected in electricity generation, as discussed in the previous section.

Environmentally sustainable mass transit was hampered by the impossibility of financing its high infrastructure costs. Had railway solutions played a greater role in the exercise we conducted for this section—especially at the expense of automotive transportation systems such as the BRT—[23] the cost would more than double, to USD 578.1 billion, by 2030.

Fortunately, the development of new electric transportation technologies (and the decrease in their costs) promises to provide cost-efficient answers to this pull between financial capacity and environmental urgency. If we consider the expected fleet renovation and the current differential between internal combustion and electric buses, it is estimated that the region could convert 20 percent of its total bus and electric bus fleet with an additional investment of USD 11 billion on top of the expected investment in fleet renewal for the 2020–30 period. Of that total, about USD 3.7 billion are linked to the necessary deployment of charging infrastructure and other complementary investments needed for a viable service.

23 The proposed combination points toward closing the coverage deficit in mass transportation with a 30 percent BRT, 20 percent suburban railways, and 50 percent subways.

Final comments on bridging the gap affecting transportation services

The calculations of the three modules we presented above show that, to achieve the targets set in SDG-9 and SDG-11, the region will need to build new infrastructure (roadways, airports, and mass transit) at the cost of USD 548.3 billion, nearly 60 percent of which is taken up by roads. Maintaining current road networks and replacing obsolescent assets—the only stock of infrastructure for which there is reliable information—would require an additional USD 427.8 billion, or a total investment of 976.1 billion. This equals a regional annual investment of 1.37 percent of GDP by 2030.

These results express other investments we consider more efficient and likelier to achieve the goals under our interpretation of the definitions in this study. But the transportation sector is undoubtedly beset with more uncertainty regarding investments needed to reach the stated goals. This is because various options might get results and sector information is scarce. Meanwhile, quantitative targets associated with the SDGs are elusive. In road transportation, since universal rural access was found infeasible, we redefined the goal, converting, as a theoretical exercise, the existing tertiary network to make it transitable year-round and expanding its coverage in line with its historic trend. In public transportation, we opted to estimate the gap-closing costs following a scenario using BRT-type solutions for 75 percent of the costs. Nevertheless, those percentages could vary from one country to another. Both assumptions, part of this report's methodology, must be considered when interpreting the results.

Additionally, for road transportation, we need to consider that solutions cannot come exclusively from investments, which often can be counterproductive, and generate more congestion and contamination. It is important to implement demand management policies that can rationalize the use of private vehicles to reduce the pressure on the existing infrastructure and, thus, reduce the projected investments (see box 4).

Box 4. The importance of demand management policies

In recent years, private vehicle use in the region has soared; its modal trip participation rising from 20.6 percent in the 1990s to 29.1 percent in the 2010s (IDB, 2020). The amount of road infrastructure in LAC has favored individual transportation *vis-à-vis* other modes: of the 277,000 km of the road networks of the 29 major metropolitan areas of the region, just 1 percent is for exclusive use of public transportation (IDB, 2020). The rise in private transport, has meant high congestion in the region: Four cities in LAC are among the world's 10 more congested (TomTom, 2020[24]), and congestion produces losses of 5 to 10 percent of regional GDP (CAF, 2018[25]). In this context, building more roads does not solve congestion, nor is it sustainable (Transportation for America, 2020). The cost of highway construction in the region averages USD 460,000[26] per lane, posing capacity limits in comparison with mass transportation systems.

In this context, the region must implement policies to discourage the private vehicle while improving public transportation. One way to discourage private cars is through congestion pricing, which changes perceptions around externalities. This policy has seen success worldwide. In Singapore, traffic volumes and emissions dropped by 15 percent, generating USD 100 million in annual income. In Stockholm, delays dropped by 30 to 50 percent, and CO_2 emissions by 14 percent, all while generating USD 155 million in annual payments (IDB, 2020).

Parking policies are another way to discourage automobile use, such as restricting the number of parking spots on public roads and streets or increasing parking costs. Christiansen *et al.* (2017) concludes that curtailing parking places is the most effective means of discouraging the use of car in work-related commutes; Auchincloss et al. (2015) analyzed 107 cities in the United States. Higher parking costs encouraged the use of public transportation. Free and abundant parking quadruples the probability of using the car (Calatayud *et al*., 2021).

24 TomTom (2020). Traffic congestion ranking | TomTom Traffic Index. Tomtom.Com. https://www.tomtom.com/en_gb/traffic-index/ranking/.
25 CAF, 2018. "América Latina necesita mejores infraestructuras urbanas". Caracas: Corporación Andina de Fomento. [Online] Available at: https://www.caf.com/es/conocimiento/visiones/2018/04/america-latina-necesita-mejores-infraestructuras-urbanas/.
26 Estimation by the IDB's Transport Division based on projects in the region.

6. REACHING THE SDGs IN TELECOMMUNICATIONS SERVICES

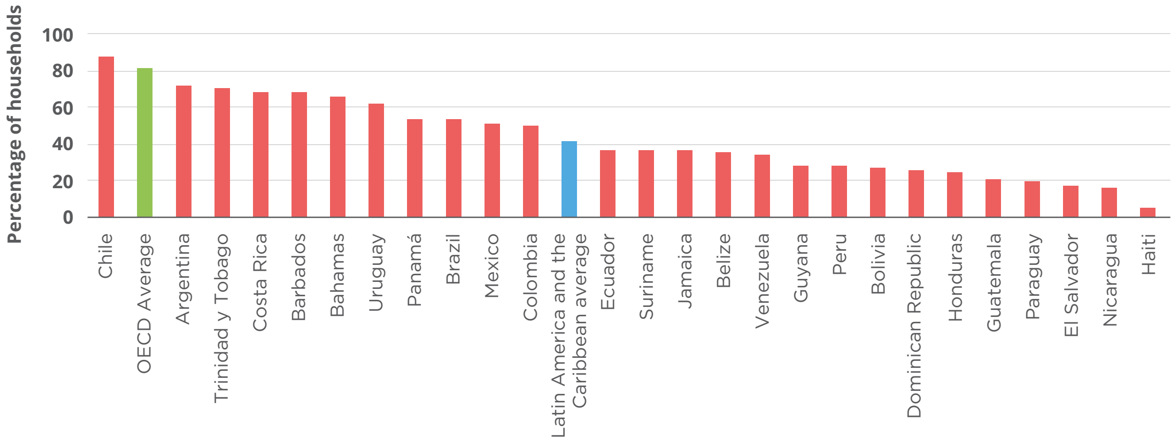
ANALYZING TELECOMMUNICATIONS SERVICES IN THE REGION

Digital connectivity is crucial to a productive and competitive economy so citizens can enjoy modern services. Delays in the adoption of telecommunication technologies will create costly bottlenecks, hindering the development of economic activities. The crises linked to COVID-19 have shown that lack of access to digital connectivity harms economic activity and productivity, conditions access to education for children, and complicates governmental management of scarce available vaccines and other types of state aid. These effects have been clearly asymmetrical for populations with different income levels. Residents of remote areas have been hit especially hard.

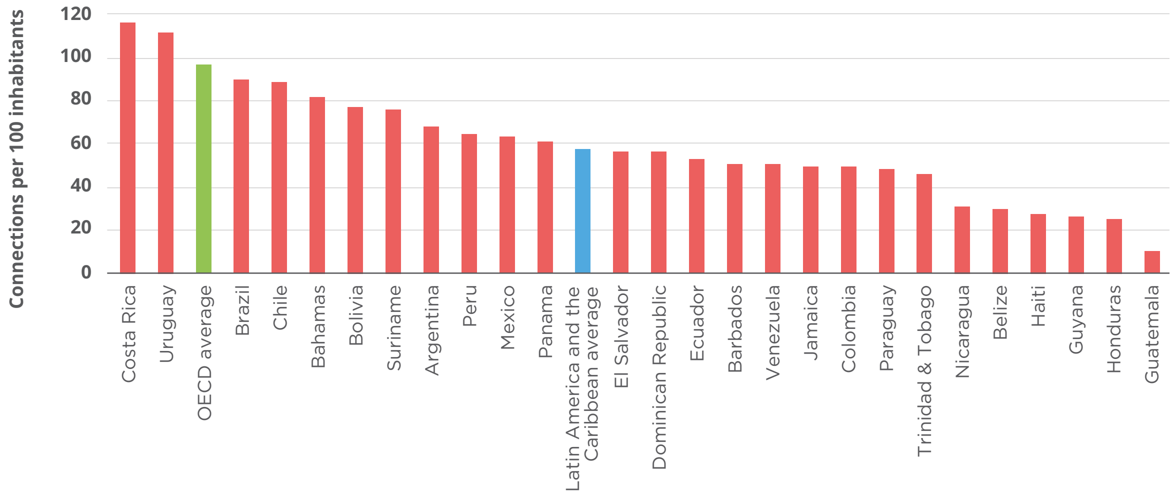
The COVID-19 pandemic has renewed awareness of the region's need to guarantee equitable access to telecommunication services that meet adequate quality standards. In 2018, only two-fifths of the households in LAC had internet access, and only two-thirds of the population had access to mobile broadband, as shown in figure 12.

Figure 12. *Access to fixed and mobile communication technologies in LAC*

A. HOUSEHOLDS WITH ACCESS TO INTERNET (IN PERCENTAGE POINTS)



B. MOBILE BROADBAND PENETRATION (CONNECTIONS PER 100 INHABITANTS)

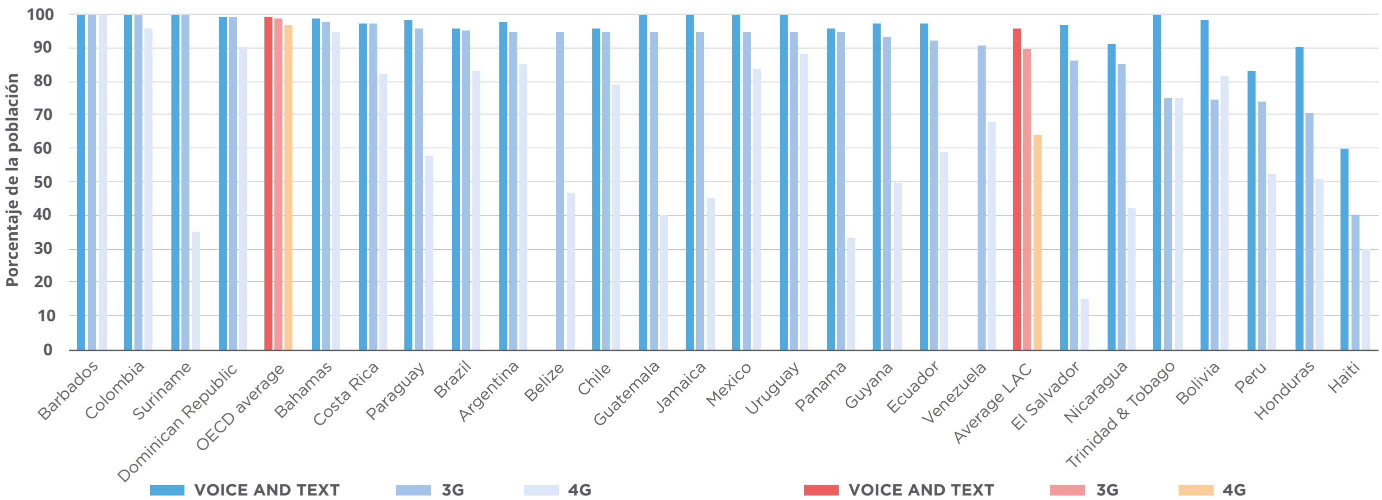


Source: Cavallo, Powell, and Serebrisky, 2020.

The levels of access to telecommunications infrastructure vary from country to country, as well as between urban and rural contexts. These disparities are generally larger in telecommunications because private participation in infrastructure deployment is more pronounced than in other sectors. Investments in this sector are mainly recovered through subscription payments; hence, investors prioritize projects that serve densely populated communities. The deployment of infrastructure generally starts in urban areas (where access approaches 100 percent in most of the region), and then expands to suburban areas before, eventually, arriving in rural areas. According to the 2020 edition of Development in the Americas (Cavallo, Powell, and Serebrisky, 2020), the result of this investment dynamic is that the access gap for mature technologies such as mobile telephones has nearly closed, whereas it remains open in the latest technologies. Indeed, by 2017, close to 89 percent of the rural population in the region had coverage of cellular mobiles networks (as compared to 93 percent in the OECD), but just 76 percent of rural population had coverage with a 3G network (as compared with 87 percent in the OECD).

This quality gap is especially pernicious in digital connectivity because the data transmission capacity of each technology conditions its applications. While OECD countries are deploying 5G networks with the necessary connectivity for services as novel as the control of autonomous cars, managing the electricity demand of home appliances ("Internet of Things"), and remote surgeries, 4G coverage in LAC in 2018 reached only 62 percent of the population (figure 13). These delays may seem minor, but their consequences are measured in orders of magnitude: the download speeds allowed by 5G networks are at least 10 times higher than those of 4G networks, latency (the frequency with which data is transmitted) is a tenth, and the number of devices which can be connected simultaneously is multiplied by 100.

Figure 13. *Population covered by different mobile connectivity technologies in LAC*



Source: Cavallo, Powell, and Serebrisky, 2020.

Lack of access and low-quality digital connectivity service translate, naturally, into low adoption rates and use of digital technologies. Several indicators suggest there is space to increase use of digital connectivity: LAC has 2.1 digital devices per capita, well below North America (8.0) and western Europe (5.4) and slightly over the global average (2.4) (Cisco, 2020). In 2017, LAC accounted for 5.7 percent of total digital data traffic in the world, below its participation both in the global economy (6.5 percent) and population (8 percent). Solving this relative delay is fundamental. It will connect the region with the world, create margins of productivity, and bring much-needed quality-of-life improvements to LAC households.

ESTIMATING THE INFRASTRUCTURE GAP AFFECTING TELECOMMUNICATIONS SERVICES

La estimación de la brecha de infraestructura para los servicios de telecomunicaciones cuenta con un módulo en el que se realizan dos estimaciones: las inversiones necesarias para garantizar el acceso a banda ancha y las inversiones necesarias para brindar una cobertura adecuada de redes para telecomunicaciones móviles.

In 2018, only two-fifths of the households in Latin America and the Caribbean had internet access, and only two-thirds of the population had access to mobile broadband.

/ P. **55**

The infrastructure gap affecting fixed broadband and mobile telecommunications services

The first difficulty to estimate the telecommunications infrastructure gap is to evaluate simultaneously the different aspects related to coverage and quality of the different technologies available to provide the services. Consequently, it is not easy to set the target for telecommunication services in line with the SDGs. SDG-9 points to "Build resilient infrastructure, promote sustainable industrialization and foster innovation," and target 9.c states: "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020." The SDGs do not offer a clear target, but they do provide a guideline. First, they say to increase access to information technology and telecommunications. This goal predetermines that the telecommunications infrastructure expansion should include different technologies allowing for multiple applications. Second, the SDGs call for universal and affordable access to the internet. Considering the coverage rates in the countries with stronger information and communication technologies (those of the OECD), mobile technologies are a clear choice. Consequently, this study has estimated the investment needs in telecommunications infrastructure with a benchmarking exercise, comparing access rates in LAC countries with those in the most advanced countries through two technologies: fixed broadband and the access to mobile internet under a 4G standard.

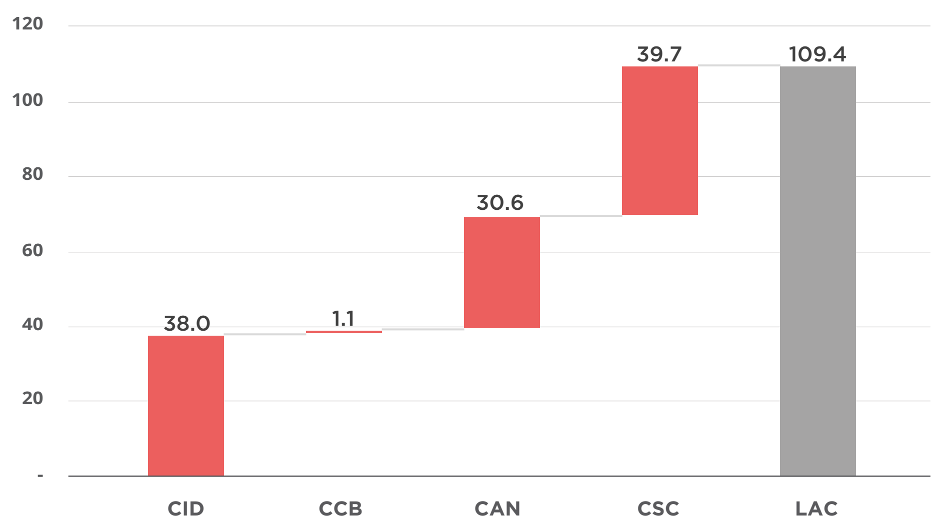
The information about coverage from fixed broadband and 3G and 4G networks comes from two sources. For fixed broadband service, we used the indicator of quantity of fixed broadband connections per 100 inhabitants reported in the World Bank's World Development Indicators. As far as 3G and 4G mobile network coverage is concerned, the data was taken from the International Telecommunication Union database, which reports the coverage of both services for the year 2018.

Once we had determined the number of citizens in the region without access to fixed broadband services or to 3G and 4G mobile technologies, we had to attribute the individual cost of connecting them in accordance with the existing technology and the expected population increase by 2030. The unit costs for the fixed broadband service were established country by country and supplied by the specialists of the Connectivity, Markets and Finance Division in the Institutions for Development Sector at the IDB. These costs support the investment gap estimate included in the Annual Report of the Broadband Development Index (García, Iglesias, and Puig, 2021) published by the IDB. For 3G and 4G mobile Internet services, the unit costs are based on Mexico's shared telecommunications network project and Peru's National Infrastructure Plan[27].

27 The Annex includes the sources of information cited here and the details of the values that were also used for calculating the gap.

According to this analysis, LAC will have to invest approximately USD 44.1 billion in new infrastructure by 2030 to equal the OECD's fixed broadband access level, and USD 18.5 billion in new infrastructure to equal its coverage level of 3G networks. If the region sought to equal the OECD's 4G standard mobile coverage, the investment amount would increase significantly, to USD 65.3 billion. To equal the OECD's coverage levels does look like a demanding target, as we mentioned in the sector diagnosis, but delaying the region's connectivity has important costs, restricting the economies' productive potential and their ability to provide modern services for households. Hence, our base scenario of the infrastructure gap will consider the investments needed to achieve the 4G standard. Consequently, new investments for approximately USD 109.4 billion will be needed by 2030 to guarantee access to fixed broadband and mobile 4G services.

Figure 14. *Total investments needed in new infrastructure through 2030 to ensure access to fixed broadband and 4G mobile networks (USD billion)*



Source: Authors' elaboration.

Note: The IDB's regional groupings take the following abbreviations: CID (Central American countries), including Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic; CCB (Caribbean Group countries): Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago; CAN (Andean Group countries): Bolivia, Colombia, Ecuador, Peru, and Venezuela; and CSC (Southern Cone countries): Argentina, Brazil, Chile, Paraguay, and Uruguay.

To have access to telecommunication services at a level comparable to that of the OECD, and on top of the investments in new infrastructure, the region will also have to make additional investments to maintain current assets and replace obsolescent ones. By 2030, the region will have to invest USD 184.3 billion in these additional investments (see the Annex for the details on the assumptions). Consequently, total investment in telecommunications will have to reach USD 293.7 billion, equal to annual investments of 0.41 percent of regional GDP. The relative importance of maintenance and asset replacement is evidently higher in the telecommunications sector than in other infrastructure services. The reason behind this is that assets must be replaced more frequently, not necessarily because they are reaching the end of their lifespan but because technological obsolescence occurs at such great speed for these assets. The following table summarizes the investment needs expected for LAC overall and in each of the region's countries.

Table 12. *Total investments needed through 2030 to ensure access to fixed broadband and 4G mobile networks (in USD millions)*

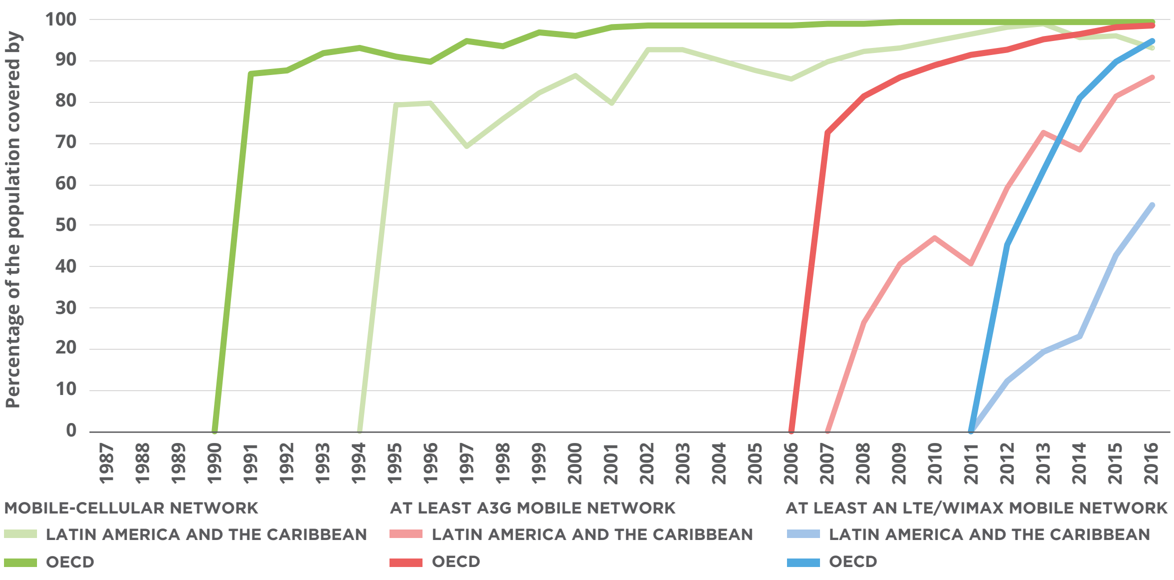
COUNTRY	INVESTMENT NEEDS				
	FIXED BROADBAND		4G		
	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	2,755	3,093	3,462	10,045	**19,356**
Bahamas	18	25	26	88	**158**
Barbados	0	22	4	59	**84**
Belize	52	31	81	114	**278**
Bolivia	1,859	989	1,747	2,676	**7,271**
Brazil	14,566	13,547	13,991	46,509	**88,613**
Chile	1,086	1,173	1,600	4,115	**7,974**
Colombia	3,238	2,944	2,065	10,877	**19,123**
Costa Rica	191	274	388	1,154	**2,007**
Ecuador	1,187	986	2,944	4,546	**9,662**
El Salvador	195	197	1,577	1,890	**3,859**
Guatemala	1,212	689	4,191	5,272	**11,363**
Guyana	110	66	100	192	**468**
Haiti	371	183	3,660	2,631	**6,844**
Honduras	872	490	2,489	2,448	**6,299**
Jamaica	86	105	448	769	**1,408**
Mexico	7,191	7,303	10,786	29,022	**54,303**
Nicaragua	681	369	1,429	1,775	**4,254**
Panama	300	258	1,010	1,272	**2,840**
Paraguay	976	532	1,087	1,867	**4,462**
Peru	3,626	2,211	6,558	7,863	**20,258**
Dominican Republic	454	390	852	2,434	**4,130**
Suriname	71	50	120	172	**413**
Trinidad & Tobago	10	75	141	275	**500**
Uruguay	9	214	119	720	**1,062**
Venezuela	2,967	1,945	4,440	7,332	**16,684**
Total	**44,086**	**38,160**	**65,314**	**146,115**	**293,675**
Annual investment (% of GDP)	**0.06%**	**0.05%**	**0.09%**	**0.20%**	**0.41%**

Source: Authors' elaboration.

Final comments on bridging the gap affecting telecommunications services

According to the estimates in this document, the investments needed in the telecommunications sector to fulfill the infrastructure component of the goals established by SDG-9 with adequate quality standards amount to USD 293.7 billion, equivalent to annual investments of 0.4 percent of regional GDP. These estimates are very sensitive to the quality standards we define. When analyzing this sector, it is important to bear in mind that a delay in fulfilling the coverage goals slows down economic development, preventing improvements that translate into productivity gains in economic sectors and a better quality of life for the region's households. The COVID-19 pandemic has, in this sense, provided a dramatic lesson. Despite this, it is true that the region has compressed the time needed to deploy telecommunications infrastructure in comparison with the most advanced countries, as shown in figure 15. LAC must make sure this trend continues, as it is key to develop modern, digital, and productive economies.

Figure 15. *Deployment of mobile telecommunications technologies, Latin America and the Caribbean vs. OECD*



Source: Cavallo, Powell, and Serebrisky, 2020.

7. LIMITATIONS OF THE ESTIMATES

For several reasons, these estimates of LAC's infrastructure gap fall at a lower bound of investment needs. First, the needs estimated in this exercise are linked to the SDGs tied directly to the provision of infrastructure services. But such provision is indirectly linked to other SDGs, such as those touching on the preservation of marine natural resources (SDG-14) and life on land (SDG-15).

Second, these estimates arise out of the investments in building infrastructure. But, as highlighted in the 2020 edition of Development in the Americas (Cavallo, Powell, and Serebrisky, 2020), regulatory interventions are required to improve service provision and they go beyond the construction of infrastructure; policies of this kind have an impact on the SDGs and can be cost-effective, especially in the context of the path out of the COVID-19 pandemic.

A third limitation is that this document represents an exercise in reasonably estimating the investments we deem standard to close the infrastructure gaps; it does not contemplate, however, other necessary investments whose estimation would require a more in-detail analysis of specific country- or even city-level conditions. Among these investments we can find, to name some examples, those in water catchment, storage, and treatment.

Additionally, the preliminary investments we present do not include complementary investments needed to fulfill all the SDGs linked to climate change; for example, recent estimates for LAC show that meeting the energy efficiency goals linked to the use of refrigerators could require an investment of about USD 8 billion up to 2030 (Urteaga, 2020); similar investments to electrify public transformation, for example, could increase the investment needs in more than USD 11 billion.

Finally, we estimated the investment needs and maintenance for all the modules where reasonable estimates were possible, looking at the existing stock of infrastructure with the information we had available. The information limitations have meant that for some modules (airports, for example) we were not able to estimate maintenance and replacement of existing assets; in other modules, such as electricity generation assets, we were able to supply only partial estimates. Consequently, these limitations mean our estimates are minimum, indispensable amounts; requirements could eventually be higher than the estimates suggest.

8. CONCLUSIONS

This study presents an exercise where we calculate the investments needed to expand and maintain the infrastructure necessary to fulfill the SDGs that are directly linked to services. Modeling investment needs aims to provide specialists and policymakers with a tool that, with explicitly stated assumptions, can make consistent estimates and quantify the investment effort required at country and sector levels. Many of the assumptions are model parameters, easily modified to evaluate their impact in the magnitude of the calculated values. The modeling we made is available in a spreadsheet freely accessible for anyone to change the parameters and assumptions and to adjust the calculations to specific questions and detailed information on costs for the different infrastructure services we modeled. The spreadsheet can be downloaded from **https://interactive-publications.iadb.org/La-brecha-de-infraestructura-en-America-Latina-y-el-Caribe**

We wish to stress that these estimated investments do not imply the total fulfillment of the SDGs related to infrastructure service provision. Apart from the limitations in the calculation of the investments, duly explained in the Annex, the SDGs set comprehensive goals which incorporate other criteria such as affordability, resilience, and sustainability which imply public policies which go beyond the necessary investments to provide more and better infrastructure. Some examples of those policies are subsidies targeting, demand management policies, and rethinking infrastructure design to respond to risks of disasters and the effects of climate change.

In this sense, the estimates in this study should be seen as a lower bound, over which additional calculations can be made to supply more sustainable services; this would require investments that attain a higher penetration of renewable energies in the regional energy mix, transmission lines to strengthen the regional integration of electricity systems, infrastructure works for flood control, water and sanitation networks resilient to natural disasters, and investments in green infrastructure to guarantee water quality and quantity in the context of climate change, among others.

Under our base scenario, the global result is that, by 2030, the region needs to invest USD 2,220.7 billion to expand and maintain the necessary infrastructure to fulfill the SDGs in the water, sanitation, electricity, transportation, and telecommunication sectors. Of that amount, 59 percent is taken up by new infrastructure investment—41 percent to maintain existing assets and replace obsolescent assets that are indispensable for infrastructure services with adequate quality standards. The investment effort will require Latin America and the Caribbean to invest at least 3.12 percent of its GDP every year by 2030.

In the country-by-country analysis, and following the grouping adopted by the IDB, the investment needs break out in the following way: the countries of Central America, Haiti, Mexico, Panama, and the Dominican Republic (CID), USD 612.8 billion; the countries of the Caribbean Group (CCB), USD 19.6 billion; the countries of the Andean Group (CAN), USD 457.9 billion; and the countries of the Southern Cone (CSC), USD 1,130.4 billion. On a per capita basis, the region will need to invest USD 282 per capita per year up to 2030. In the countries of the Southern Cone (CSC), the needed investment amounts to USD 322 per capita, followed by the countries of the Andean Group and the Caribbean (CAN and CCB) with USD 259 and 251 per capita annually, respectively, and the countries of Central America (CID) with USD 243 per capita.

Table 13. *Investment needed through 2030 to fulfill the infrastructure component of the SDGs in Latin America and the Caribbean, by IDB region (USD billion)*

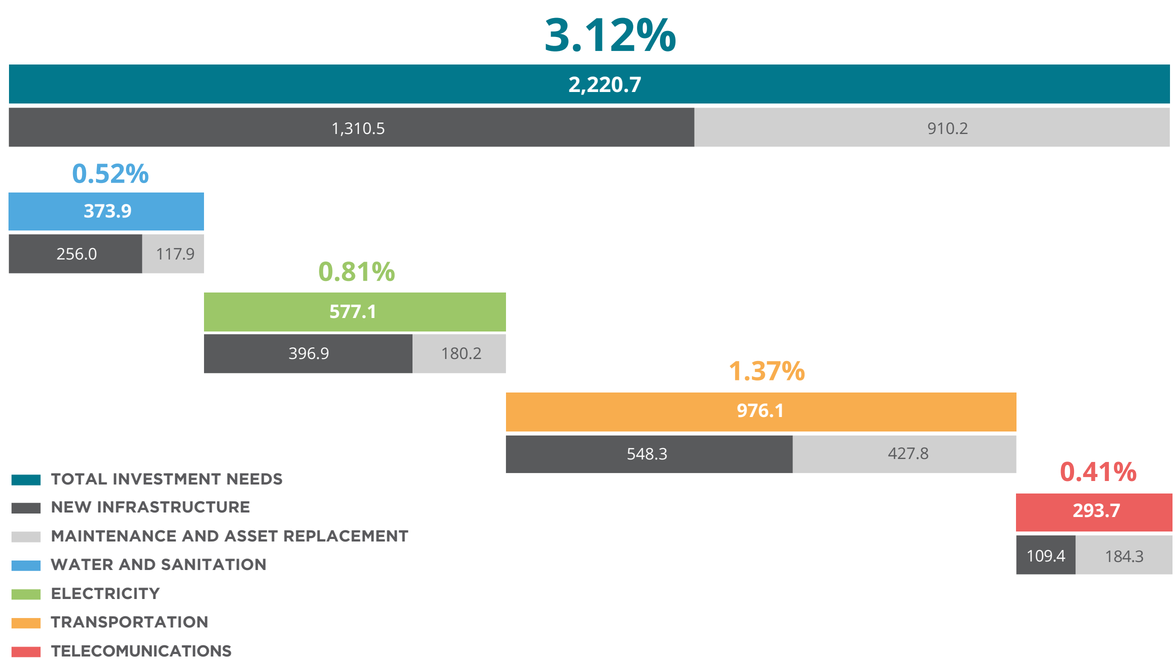
REGION	COUNTRIES	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL	ANNUAL PER CAPITA INVESTMENT
Central American countries (CID), plus Haiti, Mexico, Panama, and Dominican Republic	Belize, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Mexico, Panama, and Dominican Republic	382.7	230.1	612.8	**243***
Caribbean Group countries (CCB)	Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago	10.0	9.5	19.6	**251***
Andean Group Countries (CAN)	Bolivia, Colombia, Ecuador, Peru, and Venezuela	283.3	174.7	457.9	**259***
Southern Cone Countries (CSC)	Argentina, Brazil, Chile, Paraguay, and Uruguay	634.6	495.9	1,130.4	**322**
Total LAC		**1,310.6**	**910.2**	**2,220.7**	**282**

Source: Authors' elaboration.

***Note: The Annex provides country-level information on the investment needs and information availability for the calculation of the gap for each service. In cases such as the CID and CCB countries and Venezuela, lack of information drives the calculation down.**

In a sector-by-sector analysis, closing the access gap and maintaining the service quality in water and sanitation, including treatment of wastewater, requires an annual investment effort of 0.5 percent of regional GDP. In the electricity sector, Latin America will need to invest an average of 0.8 percent of its GDP annually to provide universal access to electricity to all the population and move forward in the decarbonization of the electricity generation mix, in line with the countries' expansion programs. In the transportation sector, closing the gaps in road infrastructure, airports, and public transportation will demand an annual investment of 1.4 percent of regional GDP. Finally, in the telecommunications sector, increasing households' connectivity with fixed broadband and 4G standard mobile Internet will require an average annual investment of 0.4 percent of GDP up to 2030.

Figure 16. *Annual investment effort as a percentage of regional GDP, per sector (total investments, 2019–30, USD billion)*



Source: Authors' elaboration.

These results show that LAC will need to invest much more in infrastructure than it did before the pandemic, when annual average investment (public and private) was 1.8 percent of GDP for the 2008–19 period. This increased investment will challenge the region at a time when both the economy and the fiscal space have deteriorated (Izquierdo *et al.*, 2020), and in which, additionally, investments in infrastructure have been reduced by the economic downturn associated with COVID-19 in Latin America and the Caribbean.

Of the estimated USD 2,220.7 billion in investment needed to reach SDGs, 47 percent is linked to SDG-9, along with investments in road, airport, and telecommunications infrastructure. Investments linked to SDG-7 follow, requiring 26 percent of investment. SDG-6 is third, at 17 percent of the total. Finally, fulfilling SDG-11 relative to urban mass transit represents 10 percent of total estimated investments.

Figure 17. *Investments required through 2030 to close infrastructure gaps, by SDG*

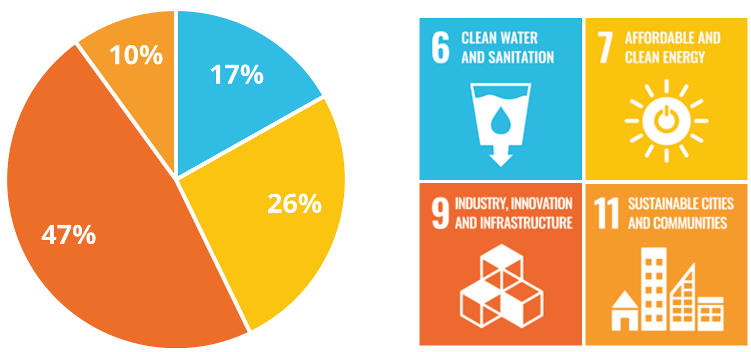


Table 14. *Investments required through 2030 to close infrastructure gaps, by SDG*

SUSTAINABLE DEVELOPMENT GOALS (SDGs)	INVESTMENT (BILLION USD)	PERCENTAGE
GOAL 6: Ensure access to water and sanitation for all	373.9	17%
GOAL 7: Ensure access to affordable, reliable, sustainable and modern energy	577.01	26%
GOAL 9: Bild resilient infrastructure, promote sustainable industrialization and foster innovation	1,047.4	47%
GOAL 11: Make cities inclusive, safe, resilient and sustainable	222.4	10%
Total	**2,220.7**	**100%**

Source: Authors' elaboration.

Table 15 shows how much each country in the region must invest by 2030 to meet the infrastructure component of the SDGs.[28] At the same time, the executive summary consolidates the graphic analyses for each sector. Additionally, the Annex provides the available information for calculating the infrastructure gaps in each of the region's countries, with the disaggregated results.

28 The investment needs are calculated using the final year having information on infrastructure service access and quality for each of the sectors. Given that in the 2008–19 period the region invested 1.8 percent of GDP annually, and that the economic crisis generated by COVID-19 to a large extent stopped investments in 2020–21, it is to be expected that in 2019–21 the region accumulated a delay in investments compared to the 3.12 percent of GDP annual investment estimated by this document. Hence, an additional investment would be needed in the following years to 2030 to compensate for this delay.

Table 15. *Total investments needed by country through 2030 to expand and maintain the infrastructure necessary to fulfill the SDGs linked to infrastructure services (in USD billions)*

COUNTRY	NEW INFRASTRUCTURE	MAINTENANCE AND ASSET REPLACEMENT	TOTAL
Argentina	113.5	90.9	**204.4**
Bahamas	0.2	0.2	**0.4**
Barbados	0.2	0.2	**0.3**
Belize	1.6	0.3	**1.9**
Bolivia	32.4	22.9	**55.3**
Brazil	452.4	348.7	**801.1**
Chile	47.6	41.5	**89.2**
Colombia	100.1	69.0	**169.0**
Costa Rica	13.3	11.4	**24.7**
Ecuador	46.3	25.7	**71.9**
El Salvador	15.0	5.4	**20.4**
Guatemala	30.6	17.6	**48.2**
Guyana	1.3	0.6	**1.8**
Haiti	20.6	7.9	**28.6**
Honduras	16.5	8.9	**25.4**
Jamaica	5.6	6.2	**11.9**
Mexico	240.3	153.4	**393.7**
Nicaragua	11.2	7.5	**18.6**
Panama	12.3	6.7	**19.0**
Paraguay	13.1	9.5	**22.6**
Peru	70.5	39.6	**110.1**
Dominican Republic	21.2	11.0	**32.2**
Suriname	1.1	0.9	**2.0**
Trinidad & Tobago	1.7	1.4	**3.1**
Uruguay	8.0	5.2	**13.2**
Venezuela	34.0	17.6	**51.6**
Total	**1,310.5**	**910.2**	**2,220.7**

Source: Authors' elaboration.

This report presents boxes throughout the sections presenting valuable information about external studies that estimate investments in some components not included in our calculations. Compared with investments we did estimate, their magnitudes are low. Investments in water storage, for example, for the use of populations would entail an investment effort of 0.005 percent of regional GDP. And as for ports and the additional investment to electrify transport fleets, the investment effort required amounts to 0.02 percent of regional GDP each.

REFERENCES

Acevedo, M. C., E. Borensztein, and J. Lennon. 2019. "Development Gaps: Methodological Innovations and Inclusion of Private Sector Indicators." Inter-American Development Bank, Washington, DC.

Auchincloss, A. H., R. Weinberger, S. Aytur, A. Namba, and A. Ricchezza. 2015. "Public Parking Fees and Fines: A Survey of U.S. Cities." Public Works Management and Policy.

Bain, R., R. Johnston, F. Mitis, C. Chatterley, and T. Slaymaker. 2018. "Establishing Sustainable Development Goal Baselines for Household Drinking Water, Sanitation and Hygiene Services." Water 10(12).

Bonifaz, J. L., R. Urrunaga, J. Aguirre, and P. Quequezana. 2020. "Brechas de infraestructura en la región andina." Discussion paper IDB-DP-00807. Inter-American Development Bank, Washington, DC.

Bonifaz, J. L., R. Urrunaga, J. Aguirre, and P. Quequezana. 2019. "Brecha de infraestructura en el Perú: Estimación de la brecha de infraestructura de largo plazo 2019-2038." IDB monograph 838. Inter-American Development Bank, Washington, DC.

Brichetti, J.P., Giraldez Zuniga, F., Sanchez Gonzalez, S. and T. Serebrisky. 2021. "La brecha de acceso a la infraestructura aeroportuaria en América Latina y el Caribe." Unpublished study. Inter-American Development Bank.

BRTData. Statistical information by city.

Calatayud, A., and L. Montes, eds. 2021. "Logística en América Latina y el Caribe: Oportunidades, desafíos y líneas de acción." IDB monograph 921. Inter-American Development Bank, Washington, DC.

Calatayud, A., S. Sánchez, F. Bedoya, F. Giraldez, and J. Márquez. 2021. "Congestión urbana en América Latina y el Caribe: Características, costos y mitigación." Inter-American Development Bank, Washington, DC.

Calderón, C., A. Fernández Gómez Platero, and Z. Wanner. 2020. "The Development Conversation about Infrastructure: Energy, Transportation, Water and Sanitation." Technical Note 1800. Inter-American Development Bank, Washington, DC.

Castillo, T., F. García, L. Mosquera, T. Rivadeneira, K. Segura, and M. Yujato. 2019. "Panorama energético de América Latina y el Caribe 2018." Report. Organización Latinoamericana de Energía (Latin American Energy Organization–OLADE), Quito.

Cavallo, E., A. Powell, and T. Serebrisky, eds. 2020. *From Structures to Services: The Path to Better Infrastructure in Latin America and the Caribbean*. Development in the Americas Series. Inter-American Development Bank, Washington, DC.

Christiansen, P., Ø. Engebretsen, N. Fearnley, and J. Usterud Hanssen. 2017. "Parking Facilities and the Built Environment: Impacts on Travel Behaviour." *Transportation Research Part A: Policy and Practice 95* (January): 198–206.

Cisco. 2020. "Cisco Annual Internet Report (2018–2023)." Technical document. Cisco, San José, CA. Available at https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html#_Toc532256803. Consulted March 2020.

CAF (Corporación Andina de Fomento–Development Bank of Latin America). 2016. "Análisis de inversiones portuarias en América Latina y el Caribe al horizonte 2040." Development Bank of Latin America, Lima, Peru.

Deichmann, Uwe, Anna Reuter, Sebastian Vollmer, and Fan Zhang. 2019. "The Relationship between Energy Intensity and Economic Growth: New Evidence from a Multi-Country Multi-Sectorial Dataset." *World Development* 124.

Energy Hub. "Investment Gap for Universal Access to Electricity by 2030." https://hubenergia.org/en/indicators/investment-gap-universal-access-electricity-2030. Consulted in August 2021.

Escobal, J., and M. Torero. 2005. "Measuring the Impact of Asset Complementarities: The Case of Rural Peru." *Cuadernos de economía* 42(125): 137–164, May.

García, A., E. Iglesias, and P. Puig. 2021. "Informe anual del Índice de Desarrollo de la Banda Ancha. Brecha digital en América Latina y el Caribe." Inter-American Development Bank, Washington, DC.

Glaeser, E., and J. Poterba. 2021. Economic Perspectives on Infrastructure Investment. ASPEN Economic Strategy Group.

Gómez-Vidal, A., F. Machado, and D. Datshkovsky. 2021. "Water and Sanitation Services in Latin America: Access and Quality Outlook." TN 2177. Inter-American Development Bank, Washington, DC.

Greenstone, M., and C. Q. Fan. 2018. "Introducing the Air Quality Life Index: Twelve Facts about Particulate Air Pollution, Human Health y Global Policy." Report. Energy Policy Institute at the University of Chicago, Chicago.

GTZ. 2003. "Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities." Eschborn, Germany.

Hutton, G., and L. Haller. 2004. “Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level.” WHO/SDE/WSH/04.04. World Health Organization, Geneva, Switzerland.

Hutton, G., and Mili Varughese. 2016. “The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene.” World Bank, Washington, DC.

IDB (Inter-American Development Bank). 2020. “Transport Sector Framework.” Transport Division. Washington, DC.

IEA (International Energy Agency). 2019. “Renewables 2019: Market Analysis and Forecast from 2019 to 2024.” Paris. Available at https://www.iea.org/reports/ renewables-2019. Consulted March 2020.

International Road Federation. Statistics: Better Road Data for Better Policies. International Road Federation, Alexandria, VA, United States. https://www.irf.global/statistics/

Iorio, P., and M. E. Sanin. 2019. “Acceso y asequibilidad a la energía eléctrica en América Latina y el Caribe.” Inter-American Development Bank, Washington, DC.

ITF (International Transport Forum). 2020. “Developing Accessibility Indicators for Latin American Cities.” Unpublished document. International Transport Forum, Paris.

ITU (International Telecommunication Union). Statistics. https://www.itu.int/itu-d/sites/statistics/

Izquierdo, A., P. Keefer, A. Blackman., M. Busso, E. Cavallo, G. Elacqua, A. Ibáñez, J. Messina, M. Mesquita Moreira, C. Scartascini, N. Schady, and T. Serebrisky. 2020. “Salir del túnel pandémico con crecimiento y equidad: Una estrategia para un nuevo compacto social en América Latina y el Caribe.” IDB monograph 827. Inter-American Development Bank, Washington, DC.

Joint Monitoring Programme, WHO and UNICEF. Statistical information.

Mikou, M., J. Rozenberg, E. Koks, C. Fox, and T. Peralta Quiros. 2019. “Assessing Rural Accessibility and Rural Roads Investment Needs Using Open Source Data.” Policy Research Working Paper 8746. World Bank, Washington, DC.

Ministerio de Economía y Finanzas de Perú. 2019. “Plan Nacional de Infraestructura para la Competitividad.” Lima.

Ministerio de Vivienda Construcción y Saneamiento de Perú. 2017. Plan Nacional de Saneamiento 2017-2021. Lima.

Ministerio de Vivienda Construcción y Saneamiento de Perú. 2014. Plan de Inversiones del Sector Saneamiento de alcance nacional 2014-2021. Lima.

Muñoz-Castillo, R., F. Miralles-Wilhelm, and K. Machado. 2019. "A CLEWS Nexus Modelling Approach to Assess Water Security Trajectories and Infrastructure Needs in Latin America and the Caribbean." Inter-American Development Bank, Washington, DC.

OECD (Organisation for Economic Co-operation and Development). 2017. *Gaps and Governance Standards of Public Infrastructure in Chile: Infrastructure Governance Review.* Paris.

Pickering, A. J., and J. Davis. 2012. "Freshwater Availability and Water Fetching Distance Affect Child Health in Sub-Saharan Africa." *Environmental science and technology* 46(4): 2391–97.

Rivas, M. E., A. Suárez-Alemán, and T. Serebrisky. 2019. "Hechos estilizados de transporte urbano en América Latina y el Caribe." IDB Technical Note 1640. Inter-American Development Bank, Washington, DC.

Rozenberg, J., and M. Fay, eds. 2019. "Beyond the Gap: How Countries Can Afford the Infrastructure They Need While Protecting the Planet." Sustainable Infrastructure Series. World Bank, Washington, DC.

Salas, D., M. Zapata, and J. Guerrero. 2007. "Modelo de costos para el tratamiento de las aguas residuales en la región." *Scientia et Technica*, diciembre, año/vol. XIII, número 037. Universidad Tecnológica de Pereira, Colombia.

Sanin, M. E. 2019. *Zooming into Successful Energy Policies in Latin America and the Caribbean: Reasons for Hope*. Inter-American Development Bank, Washington, DC.

Serebrisky, T., J. P. Brichetti, A. Blackman., and M. Mesquita Moreira. 2020. "Infraestructura sostenible y digital para impulsar la recuperación económica post COVID-19 de América Latina y el Caribe: un camino hacia más empleo, integración y crecimiento."

Thacker, Scott & Adshead, Daniel & Fay, Marianne & Hallegatte, Stéphane & Harvey, Mark & Meller, Hendrik & O'Regan, Nicholas & Rozenberg, Julie & Watkins, Graham & Hall, Jim. (2019). Infrastructure for sustainable development. Nature Sustainability.

Transportation for America. 2020. *The Congestion Con: How More Lanes and More Money Equals More Traffic*. Transportation for America, Washington, DC.

Urrunaga, R., and S. Wong. 2016. "When the Total Is More than the Sum of Parts: Infrastructure Complementarities." Working Paper 16-09. Centro de Investigación, Universidad del Pacífico.

Urteaga, J. A. 2020. “La eficiencia energética en el Sector Residencial en América Latina y el Caribe.” Unpublished conceptual note. Inter-American Development Bank, Washington, DC.

WHO (World Health Organization). SDG target 6.3.1 monitoring webpage. https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/monitoring-and-evidence/water-supply-sanitation-and-hygiene-monitoring/country-files-for-sdg-6.3.1-proportion-of-wastewater-safely-treated. Consulted in June 2021.

WHO and UNICEF (United Nations Children’s Fund). 2017. “WASH in the 2030 Agenda New global indicators for drinking water, sanitation and hygiene”.

World Bank. 2021. “Well Maintained: Economic Benefits from More Reliable and Resilient Infrastructure.” Report for the G20. World Bank, Washington, DC.

World Bank. 2020. “Well-Maintained: Economic Benefits from More Reliable and Resilient Infrastructure.” Report prepared for G-20. World Bank, Washington, DC.

World Bank. 2019a. Enterprise Survey.

World Bank. 2019b. “Measuring Rural Access: Update 2017/18.” World Bank, Washington, DC.

World Bank. 2019c. *From Waste to Resource: Shifting Paradigms for Smarter Wastewater Interventions in Latin America and the Caribbean.* Washington, DC. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/151321564553997465/from-waste-to-resource-shifting-%20paradigms-for-smarter-wastewater-interventions-in-latin-america-and-%20the-caribbean

World Bank. Road Costs Knowledge System (ROCKS). https://www.doingbusiness.org/en/reports/thematic-reports/road-costs-knowledge-system Consulted in March 2021.

World Bank. World Development Indicators. https://datacatalog.worldbank.org/search/dataset/0037712

World Bank. Population Estimates and Projections. https://datacatalog.worldbank.org/search/dataset/0037655

Yépez-García, A., Y. Ji, M. Carvalho Metanias Hallack, and D. López Soto. 2019. “The Energy Path of Latin America and the Caribbean. IDB monograph 683. Inter-American Development Bank, Washington, DC.

Yépez-García, A., M. Carvalho Metanias Hallack, A. Mejdalani, and D. López Soto. 2021. “Update on the Energy Path of Latin America and the Caribbean.” Unpublished study. Inter-American Development Bank, Washington, DC.

ACRONYMS AND ABBREVIATIONS

BNEF	Bloomberg New Energy Finance
CAF	Corporación Andina de Fomento, now Development Bank of Latin America
CAN	Countries of the Andean Group
CCB	Countries of the Caribbean Group
CID	Countries of Central America, Mexico, Panama and Dominican Republic
CSC	Countries of the Southern Cone
DIA	Development in the Americas
GDP	Gross domestic product
IDB	Inter-American Development Bank
IRENA	International Renewable Energy Agency
JMP	Joint Monitoring Programme
LAC	Latin America and the Caribbean
LAPOP	Latin American Public Opinion Project
MDG	Millennium Development Goals
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Co-operation and Development
RAI	Rural Accessibility Index
ROCKS	Road Costs Knowledge System

SDG	Sustainable Development Goals
UNICEF	United Nations Children's Fund
UN	United Nations Organization
USD	U.S. dollars
WHO	World Health Organization

ANNEX

ANNEX

Methodology for the estimation of the infrastructure gap and investment needed through 2030 to meet the Sustainable Development Goals in Latin America and the Caribbean

This Annex describes the methodologies we applied in the estimation of the infrastructure gaps in LAC to meet the SDGs by 2030. The Annex also includes details about information sources and the main assumptions used in the estimation.

A.
GENERAL ASPECTS

This section describes the calculation methodologies, information sources and assumptions for the variables that are used in more than one of the analyzed sectors (e.g. demographic estimates, GDP projections, and general computation aspects of the investment needs for maintenance and asset replacement).

A.1. Demographic variables

To estimate the infrastructure gap for household services we need to establish the population currently without access and the increase in demand linked to population growth up to 2030.

The demographic data used for these estimates were gathered from the World Bank and are based on the *World Population Prospects* developed by the United Nations' Department of Economic and Social Affairs. The database presents population and other demographic estimates and projections from 1960 to 2050 for more than 200 economies. Available information includes population data by age groups, gender, geographical setting (urban / rural), as well as fertility, mortality, and migration data, among others.

The coverage indicators of household services (water and electricity) are usually expressed as a percentage of households. Thus, we need to have data on average density or household size (inhabitants per household) to transform estimated populations in a number of households. In this study we considered two different household sizes for each country: one for urban populations and another for rural populations. We arrived to average household sizes by dividing urban or rural population by the number of dwellings in 2018. Average household size has been assumed to be fixed for all the period under analysis. However, we should bear in mind that a progressive decrease in the number of average household sizes is expected in the next years, due to an increase in income and the urbanization process in the region. In this sense, the decision to use constant average household sizes would introduce a downward bias in the estimation of the gaps in household services. This is because using higher average household sizes than the actual ones produces an underestimation of the households that would require service connection in the future. However, we expect this effect to be marginal, since the evolution of the average household sizes, though decreasing, tends to be smooth and the period under analysis is brief (2020-2030). Table A.1 summarizes the main demographic data used for this estimation.

Table A.1. *Demographic information used per country for the estimation of infrastructure gaps in LAC*

PAÍS	2018							2030						INCREASE IN DEMAND UP TO 2030	
	TOTAL POPULATION	URBAN POPULATION	RURAL POPULATION	AVERAGE HOUSEHOLD SIZE (URBAN)	AVERAGE HOUSEHOLD SIZE (RURAL)	URBAN DWELLINGS	RURAL DWELLINGS	TOTAL POPULATION	URBAN POPULATION	RURAL POPULATION	URBAN DWELLINGS	RURAL DWELLINGS	URBAN DWELLINGS	RURAL DWELLINGS
Argentina	44,361,000	40,812,120	3,548,880	3.5	3.50	11,660,606	1,013,966	49,056,162	45,996,839	3,059,323	13,141,954	874,092	1,481,348	(139,873)
Bahamas	385,640	320,178	65,462	3.30	3.30	96,926	19,817	442,321	375,973	66,348	113,816	20,085	16,890	268
Barbados	287,000	198,030	88,970	3.05	3.05	64,928	29,170	295,000	200,000	95,000	65,574	31,148	646	1,977
Belize	398,000	179,100	218,900	4.61	4.61	38,850	47,484	467,000	227,000	240,000	49,241	52,061	10,390	4,577
Bolivia	11,307,000	7,914,900	3,392,100	3.33	3.14	2,376,847	1,018,649	13,240,382	9,960,260	3,280,122	2,991,069	1,045,268	614,222	26,619
Brazil	209,469,000	180,143,340	29,325,660	2.92	3.15	61,692,925	10,043,034	223,852,116	199,172,860	24,679,256	68,209,884	7,837,868	6,516,959	(2,205,166)
Chile	17,715,000	15,766,350	1,948,650	3.01	3.01	5,237,990	647,392	19,458,098	17,731,405	1,726,693	5,890,832	573,652	652,842	(73,740)
Colombia	49,661,000	39,728,800	9,932,200	3.14	3.41	12,652,484	3,163,121	53,416,767	44,824,664	8,592,103	14,275,371	2,521,892	1,622,887	(641,229)
Costa Rica	4,999,000	3,949,210	1,049,790	3.13	3.13	1,261,728	335,396	5,468,042	4,755,229	712,813	1,519,242	227,736	257,514	(107,660)
Ecuador	17,084,000	11,104,600	5,979,400	3.58	3.88	3,101,844	1,670,223	19,818,799	13,755,121	6,063,678	3,842,213	1,562,261	740,369	(107,962)
El Salvador	6,643,000	4,118,660	2,524,340	3.43	3.68	1,200,776	735,959	6,778,592	5,297,414	1,481,178	1,544,436	402,775	343,660	(333,184)
Guatemala	17,302,000	10,035,160	7,266,840	4.01	5.18	2,502,534	1,812,180	21,212,560	14,192,050	7,020,510	3,539,165	1,355,547	1,036,631	(456,632)
Guyana	779,000	225,910	553,090	3.58	3.58	63,103	154,494	782,000	195,000	587,000	54,469	163,966	(8,634)	9,472
Haiti	11,123,000	6,117,650	5,005,350	4.75	4.98	1,287,926	1,053,758	12,733,227	8,128,494	4,604,733	1,711,262	925,000	423,336	(128,758)
Honduras	9,012,000	4,956,600	4,055,400	3.87	4.29	1,280,775	1,047,907	11,449,246	7,069,621	4,379,625	1,826,775	1,019,915	546,000	(27,992)
Jamaica	2,935,000	1,643,600	1,291,400	3.27	3.27	502,630	394,924	3,048,000	1,839,000	1,209,000	562,385	369,725	59,755	(25,199)
Mexico	126,191,000	98,428,980	27,762,020	3.49	3.83	28,203,146	7,954,734	140,875,763	112,377,095	28,498,668	32,199,741	7,435,973	3,996,595	(518,761)
Nicaragua	6,460,000	3,746,800	2,713,200	5.22	5.57	717,778	519,770	7,391,881	4,438,212	2,953,669	850,232	530,648	132,454	10,878
Panama	4,177,000	2,798,590	1,378,410	3.36	3.75	832,914	410,241	4,927,612	3,476,232	1,451,380	1,034,593	386,822	201,679	(23,419)
Paraguay	7,053,000	4,351,701	2,701,299	3.74	3.79	1,163,556	722,272	7,949,969	5,902,683	2,047,286	1,578,257	539,800	414,701	(182,472)
Peru	32,162,000	25,729,600	6,432,400	3.56	3.46	7,227,416	1,806,854	36,030,592	30,012,716	6,017,876	8,430,538	1,738,166	1,203,122	(68,688)
Dominican Republic	10,266,000	8,315,460	1,950,540	3.18	3.03	2,614,925	613,377	11,770,316	10,238,383	1,531,933	3,219,617	505,887	604,693	(107,490)
Suriname	576,000	380,160	195,840	3.90	3.90	97,477	50,215	633,000	428,000	205,000	109,744	52,564	12,267	2,349
Trinidad and Tobago	1,390,000	736,700	653,300	3.91	3.91	188,414	167,084	1,414,000	775,000	639,000	198,210	163,427	9,795	(3,657)
Uruguay	3,506,000	3,330,700	175,300	2.76	3.52	1,206,775	63,514	3,569,471	3,460,493	108,978	1,253,802	30,993	47,026	(32,521)
Venezuela	28,887,000	25,998,300	2,888,700	3.83	3.83	6,788,068	754,230	33,626,459	30,902,186	2,724,273	8,068,456	711,298	1,280,388	(42,931)
LAC	**624,128,640**	**501,031,199**	**123,097,441**	**3.59**	**3.76**	**154,063,340**	**36,249,767**	**689,707,375**	**575,731,930**	**113,975,445**	**176,280,877**	**31,078,570**	**22,217,537**	**(5,171,197)**
CID	**196,571,000**	**142,646,210**	**53,924,790**	**3.91**	**4.20**	**39,941,352**	**14,530,806**	**223,074,239**	**170,199,730**	**52,874,509**	**47,494,304**	**12,842,363**	**7,552,952**	**(1,688,443)**
CCB	**6,352,640**	**3,504,578**	**2,848,062**	**3.50**	**3.50**	**1,013,478**	**815,705**	**6,614,321**	**3,812,973**	**2,801,348**	**1,104,198**	**800,915**	**90,720**	**(14,790)**
CAN	**139,101,000**	**110,476,200**	**28,624,800**	**3.49**	**3.54**	**32,146,658**	**8,413,077**	**156,132,999**	**129,454,947**	**26,678,052**	**37,607,646**	**7,578,886**	**5,460,988**	**(834,191)**
CSC	**282,104,000**	**244,404,211**	**37,699,789**	**3.19**	**3.39**	**80,961,852**	**12,490,179**	**303,885,816**	**272,264,280**	**31,621,536**	**90,074,729**	**9,856,406**	**9,112,877**	**(2,633,773)**

Source: United Nations' World Population Prospects, accessed through the World Bank's database.

Notes: CID includes the countries which are members of the IDB's Central American Countries, Haiti, Mexico, Panama, and Dominican Republic Department; CCB includes the member countries of the IDB's Caribbean Countries Department (Bahamas, Barbados, Guyana, Jamaica, Suriname, and Trinidad & Tobago); CAN includes the member countries of the IDB's Andean Group Countries Department (Bolivia, Colombia, Ecuador, Peru, and Venezuela); CSC includes the member countries of the IDB's Southern Cone Countries Department (Argentina, Brazil, Chile, Paraguay, and Uruguay).

A.2. GDP projections

Although in all cases we calculated the infrastructure gaps in current dollars, this document also presents the results in terms of percentages of GDP, to show the investment efforts necessary to close the gaps in relative terms. The GDP data used are those consigned for the region in the International Monetary Fund's (IMF) World Economic Outlook (WEO) webpage[29]. According to that source, the regional GDP in 2019 was USD 5,192.1 billion.

At the same time, the gap calculation is a prospective exercise that needs projections on the region's economic growth to estimate the investment effort. Estimating the future economic growth of each of the countries exceeds the purpose of this document. Hence, we have used the average of the growth rates estimated by the IMF's WEO for the years of post COVID-19 recovery (2023-2026), and extrapolated them to the end of the period under analysis (2030).

The annual investment effort expressed as a percentage of the regional GDP reported in this study was computed with the following formula::

$$\bar{\beta} = \frac{1}{12} \sum_{t=2019}^{t=2030} \frac{I_t}{PBI_{2019} \times (1+\gamma)^{t-2019}}$$

Where:

$\bar{\beta}$: Annual investment effort (as a percentage of regional GDP)

I_t : Total investment made in each year to close the gaps

PBI_{2019} : LAC's GDP reported by the World Bank for 2019

γ : Expected annual GDP growth rate

29 Updated to April, 2021.

A.3. General aspects of the calculation of investment needs for maintenance and asset replacement

The calculation of the gaps includes maintenance costs and the replacement of the infrastructure needed to provide the services. In this regard, it is important to note that:

1. The maintenance costs included in the calculations were estimated as those required to allow the infrastructure assets to continue functioning optimally throughout their expected lifespan. At the same time, we add the investments necessary to replace the assets once they reach the end of their expected lifespan. To determine the profile of the replacement of existing assets we have assumed that existing investments have been made on a smoothed way; that is, without temporal discontinuities in the investment processes.

2. The investments necessary to cover maintenance costs are not neutral to the investment profile selected to close the infrastructure gaps. As part of this study, we computed two possible investment profiles for closing the gaps. The first assumed constant investments in nominal terms; that is, that the same amount is invested each year. The second profile assumes that the countries invest each year a constant percentage of their GDPs; in practical terms, and given the expected economic growth, this implies increasing investment amounts. For the calculation of the investment efforts we present in this study we have assumed the first investment profile; that is, constant investments in nominal terms.

B.

CALCULATION OF THE INFRASTRUCTURE GAP AFFECTING ELECTRICITY SERVICES

In this study, the infrastructure gap was estimated considering two dimensions of the electricity sector: guaranteeing universal access to electricity, and guaranteeing sufficient electric energy supply, based on the estimates of the IDB's Energy Division.

B.1. Calculation of the infrastructure gap affecting access to electricity

To calculate the infrastructure gap and the investments that would guarantee universal access to electricity, we had to set a goal to fulfill in terms of the relevant SDG, collect information on electricity access levels in urban and rural areas in each country, set the unit costs of providing access, and define a methodology for the calculation of the investments in maintenance and asset replacement.

B.1.1. Goal definition according to the relevant SDG

In this case, the relevant goal is SDG-7, which states: "Ensure access to affordable, reliable, sustainable and modern energy for all". Hence, to close the gap the goal is that 100% of the urban and rural households have electricity by 2030.

B.1.2. Information sources for the indicators on access to electricity

As we stated in the present study, the baseline information on electrical service access comes from the existing estimates produced by the IDB's Energy Division. Specifically, the source is the Energy Hub's estimates of the investment gaps to achieve residential Universal Access to Electricity in LAC.

B.1.3. Unit costs

To determine the unit costs of providing access to electricity to unconnected households, we identified four relevant costs of the infrastructure solution deemed more convenient among the following options: the cost of connecting to the urban network; the cost of connection and rural network expansion; the cost of connecting to an isolated rural system configured as a *mini-grid*; and the cost of connecting to an individual isolated rural system. Each of these costs was estimated at country-level.

We determined the proportion of households that required each type of solution following the Energy Hub's study that estimates the investment gaps to achieve residential Universal Access to Electricity in LAC. Adding the different gaps identified at country level, we obtained average costs at a regional level, resulting in a unit cost of 832 dollars per urban household and 1,989 dollars per rural household.

B.1.4. Methodology for the estimation of the infrastructure gap in electricity

The methodology to calculate and value the infrastructure gap to guarantee access to electricity was the following:

- First, we determined the number of urban and rural households per country without access to electricity.
- Second, we determined the increase in households up to 2030, according to the expected population growth. (We estimated this by dividing the total expected increase in population by average household sizes for 2018 by geographical area, i.e. urban or rural).
- Third, we multiplied the number of households by the corresponding unit cost; that is, we calculated the investments necessary to provide access to both the existing households without service and the new projected households up to 2030, with different unit cost depending on urban or rural context.

B.1.5. Methodology for the estimation of maintenance and asset replacement costs

To estimate the necessary investments to maintain the network in an optimal condition we needed to estimate the value of the existing stock of infrastructure. Given the available information, we multiplied the number of households connected to the electricity grid, both in urban and rural contexts, by the previously defined average unit costs. Additionally, we used linear depreciation over the value of the stock of infrastructure to represent the loss of the assets' value as a result of their use in time.

The annual investment amounts needed to cover asset replacement are the annual payments needed to replace the net value of existing assets assuming a 30 year lifespan. The infrastructure maintenance cost, meanwhile, was estimated using a 2% annual coefficient on the estimated value of total assets, including new investments.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified.

B.2. Calculation of the infrastructure gap affecting electricity generation and transmission

To calculate the infrastructure gap in electricity generation and transmission we had to set the goal to fulfill according to the relevant SDG, collect information on the expected increase of electricity demand, and estimate the investment needs associated with them.

B.2.1. Goal definition according to the relevant SDG

In this case, the relevant goal is SDG-7; more specifically, targets 7.1 ("By 2030, ensure universal access to affordable, reliable and modern energy services") and 7.2 ("By 2030, increase substantially the share of renewable energy in the global energy mix"). Since there are no explicit quantitative goals on investments on transmission and generation, nor is there any quantitative indication on the reconversion of the energy mix, we decided to accept the investment path set out in a study by IDB specialists (Yepez-Garcia, Ji, Hallack, and Lopez Soto 2019) and its recent update (Yepez-Garcia, Hallack, Mejdalani, and Lopez Soto 2021). Based on the electricity generation expansion plans of the countries of LAC and on estimates on the increase in the demand for electricity, those documents calculate the investment needs for the 2020-2030 period to expand electricity generation (in line with the objectives set out by each country's energy policy), and to replace power generation plants that reach the end of their lifespan.

Electricity generation expansions plans are usually reevaluated periodically to adapt them in a way that is consistent with the nationally determined contributions and other intermediate climate goals, with increasing ambition in line with the goals set within the Paris Agreement. This could suggest that the countries will incorporate a higher proportion of renewable sources to comply with more ambitious commitments. Increasing the participation of renewable energies generally has impact not only on generation needs, but also on the complementary investments needed to adequately manage a network that can guarantee energy security with the intermittency associated with these new energy sources. Bearing in mind target 7.2, it is important to highlight that the resulting energy mix not only guarantees the supply of electricity for the expected demand, but also increases the participation of unconventional renewable technologies in electricity generation in LAC from 7.9% to 17.1%. It also increases in aggregate terms the percentage of emission-free generation, which is estimated to grow from 63.4% to 70.4%. These metrics are directly associated with the aim of reducing the emission of greenhouse gases, because emissions per GWh decrease in more than 23% between 2020 and 2030.

Having said that, these investments should be considered a lower bound in terms of the efforts towards climate change mitigation, because this scenario might not be totally in line with goal 2 of the Paris Agreement to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

This is because the estimates are not directly associated with a scenario of deep decarbonization of the economies towards zero net emissions, nor does it entail the electrification of different components of demand currently covered by more contaminating energies (which would require more power), nor does it consider investments for technological change or other efforts to reduce the use of other energy sources, such as in the industrial sector or in transportation.

B.2.2. Information sources to determine the expected increase in electricity demand

The expected electricity demand was estimated following Yepez-Garcia, Ji, Hallack, and Lopez Soto (2019) and its recent update Yepez-Garcia, Hallack, Mejdalani, and Lopez Soto (2021). These papers estimated future electricity demand following an econometric methodology that uses as inputs the main determinants of electricity demand according to the literature (GDP, price of oil, price of electricity, among others) and calibrating the estimation parameters based on the observations of the 1971-2019 period.

In order to set the investment needs of this study we used the electricity demand estimates contained in Yepez-Garcia, Hallack, Mejdalani, and Lopez Soto (2021), which predict a 2.8% annual increase in regional electricity demand. This scenario exceeds the increase of electricity demand during the last decade (an annual average of 1.8%). Projected demand exceeds the historical average because of the trend towards electrification in the region, the expected increases in GDP, which impacts the consumption of electricity[30] in a non-linear way, and the expectation that the gap in access to electricity will be reduced during the next decade. As a consequence, to fulfill the aim of achieving universal access to electricity, the region will need to expand generation capacity to meet the increasing demand.

B.2.3. Estimation of the investment needed to close the gaps in electricity generation and transmission

The estimates of the investment needed to close the infrastructure gap in electricity generation and transmission are those of Yepez-Garcia, Hallack, Mejdalani, and Lopez Soto (2021).

For generation investment needs, the authors followed these steps:

- First, a value was calculated for the investments necessary to meet the available expansion plans of the countries of the region up to 2030; this calculation was done for each country and for each generation technology, giving a value to the expansions expressed in terms of capacity, according to the unit costs informed by the United States National Renewable Energy Laboratory (NREL).

30 See the evidence presented by Deichmann et al. (2019), which used a panel of 137 economies for the 1990-2014 period.

- Second, the authors calculated the additional electricity generation needed to cover the gap between the demand estimated with the econometric models and the average generation, according to the capacity that arises from the goals of the expansions plan for the 2020-2030 period. With each country's policies for the sector in mind, the additional electricity generation needs per technology were estimated considering the energy generation mix of the expansions plans up to 2030 (or the last year of the plan, accordingly). Using the NREL model's average load factors, the need for new generation per technology is transformed into requirements to install new power each year. Finally, this additional generation needs are assigned a value using the unit prices reported by NREL.

- Third, the investment needs linked to the depreciation of the current generation infrastructure stock are analyzed at plant level. This is done by determining the end of each plant's lifespan according to its technology and computing the cost of replacing all the installed capacity which reaches the end of its lifespan in the 2020-2030 period.

For transmission investment needs, the authors followed this methodology:

- The estimation was made computing the historical regional average of the expansion needs of the transmission networks per each GWh of demand.

- Multiplying that coefficient by the planned increase in electricity demand, the authors obtained the additional quantity of kilometers of high voltage lines required to provide the service.

- The valuation of the required investments was made using the cost of a kilometer of 400kv transmission line, taken from the World Bank's META model[31].

Finally, two additional scenarios were estimated in regard to the cost of the new infrastructure; this was done to quantify the impact of the expected cost reduction of unconventional renewable generation (solar, wind, and bio-fuels) in the next decade. The first scenario is based on the cost reduction trend of the last 4 years as reported by IRENA; the second is based on the unconventional renewable generation costs projected by BNEF.

31 The Model for Electricity Technology Assessment (META) was developed by Chubu Electric Power Corp Inc. and Economic Consulting Associates by commission from the World Bank's Energy Sector Management Assistance Program (ESMAP). META shares costs and performance data of the different electric generation, transmission, and distribution technologies, considering the different market trends and the latest technological developments.

C.
CALCULATION OF THE INFRASTRUCTURE GAP AFFECTING WATER AND SANITATION SERVICES

Using JMP's definitions, this study estimated the infrastructure gap to: i) guarantee access to safely managed drinking water; ii) guarantee access to safely managed sanitation; and iii) achieve wastewater treatment in urban areas.

C.1. Calculation of the infrastructure gap affecting safely managed drinking water

To calculate the infrastructure gap and the investments needed to provide universal access to safely managed drinking water we had to set the goal to achieve according to the relevant SDG, collect information on the level of access to drinking water (under the different standards of service in urban and rural areas), determine the unit costs of providing access, and define a methodology to calculate the gap and a methodology for the calculation of the investment in maintenance and asset replacement.

C.1.1. Goal definition according to the relevant SDG

In this case, the relevant goal is SDG-6 and, more specifically target 6.1 which states: "By 2030, achieve universal and equitable access to safe and affordable drinking water for all". Consequently, to close the gap the goal is that 100% of urban and rural households have access to safely managed drinking water services by 2030.

C.1.2. Information sources for indicators on access to water

For drinking water service coverage in LAC we used the information available at the JMP, which reports access rates under the basic and safe standards.

C.1.3. Unit costs

To obtain the unit costs of providing access to drinking water under the different standards of service we used information from several sources. We had access to several IDB projects and to the expert advice of specialists in the field. These were the main projects we used as information sources: Peru's National Infrastructure Plan, by Bonifaz *et al.* (2019); Dominican Republic's National Infrastructure Plan (to be published); the estimation of the infrastructure gap for the countries of the Andean Community; and the analysis of specialists based on operative projects in Panama and Paraguay.

Additionally, we used information on unit costs reported by Hutton and Varughese (2016). This study was conducted by the World Bank as a background paper for its "Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet" report. That report details unit costs per country of different solutions which can provide access to drinking water and sanitation services under several quality standards and includes information for 24 countries in LAC.

Table A.2. summarizes the costs we gathered, expressed in dollars per person served. These values are related to two of the standards set by the JMP: a standard defined as basic, meaning access to an improved source of water less than 15 minutes from the household; and a standard defined as safe, meaning drinking water from an improved source within the household and free of contamination. The values used to calculate the gap presented in this study are highlighted.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified

Table A.2. *Unit costs per inhabitant to provide access to drinking water service, by connection standard (USD per inhabitant)*

SECTOR	PERU STUDY	CAN STUDY			
		COLOMBIA	ECUADOR	PERU	TOTAL
WATER					
Basic Water Urban	354.85	280	246.31	945	354.85
Basic Water Rural	807.58	280	487.82	945	807.58
Safe Water Urban	1,887.09				1,887.09
Safe Water Rural	1,887.09				

SECTOR	DOMINICAN REPUBLIC STUDY	INFORMATION FROM WSA SPECIALISTS		HUTTON AND VARUGHESE (2016)	
		PANAMA	PARAGUAY	LAC AVERAGE	LAC MEDIAN
WATER					
Basic Water Urban	195	750	160	245.14	219.25
Basic Water Rural	536			144.02	58.20
Safe Water Urban	1,195	1,144	240	465.69	370.75
Safe Water Rural	1,195	438		417.54	337.20

C.1.4. Methodology for the estimation of the infrastructure gap in safely managed water

The methodology to calculate and value the infrastructure gap to guarantee access to safely managed drinking water was the following:

- First we determined the total number of households per country, both urban and rural, with basic access to drinking water and with access to safely managed drinking water, according to JMP's definitions. Additionally, we estimated the number of households which did not have access to a drinking water service with either of those standards.

- Second, we determined the expected increase of the number of households up to 2030, according to the expected population growth. This estimation was done by dividing the expected increase in population by the inhabitants per household for 2018 by geographical area (urban / rural).

- The third step was to multiply the households requiring access by the corresponding unit cost. We used the cost of a new safely managed drinking water connection for both the new households resulting from demographic growth and for those which did not have access to basic drinking water services. For the households which only had access to basic drinking water services, we used the unit cost of an upgrade, which we obtained as the difference between the cost of a safely managed water service connection and the cost of a basic water service connection.

As we mentioned in this study, there is a relevant methodological clarification for the countries for which we had no information on water service coverage by quality standards (basic or safe); in this case we made two alternative assumptions:

1. Assuming that all households with access to drinking water services had it with the safely managed water standard. This assumption underestimates the real gap, and, thus, the investment amounts obtained with it are to be considered minimum indispensable bounds.

2. Assuming that all households with access to drinking water services had it with the basic water standard. This assumption overestimates the real gap, and, thus, the investment amounts obtained by it are to be considered maximum levels.

Our knowledge of the sector's reality leads us to think that it is probably closer to the truth to assume that, in the countries lacking information, households that report access do not have access to safely managed water but rather only basic access; consequently, they would require additional investments.

C.1.5. Methodology for the estimation of maintenance and asset replacement costs

To estimate the necessary investments in maintenance for optimal drinking water services, we had to estimate the value of the existing infrastructure stock. Given the available information, we multiplied the number of households depending on their connection category (basic water, safe water), both urban and rural, by the previously determined unit costs. Additionally, we used linear depreciation over the value of the stock of infrastructure to represent the loss of the assets' value as a result of their use in time.

The annual investments necessary to cover the replacement of assets are fixed as annual amounts that allow the replacement of the net value of existing assets considering a lifespan of 30 years. The infrastructure maintenance cost, meanwhile, was estimated using a 2% annual coefficient on the estimated value of total assets, including new investments.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified.

C.2. Calculation of the infrastructure gap affecting safely managed sanitation

To calculate the infrastructure gap and the investments necessary to guarantee access to safely managed sanitation services we had to set the goal to fulfill according to the relevant SDG, collect information relative to access to sanitation (under the different service standards in urban and rural areas), determine the unit costs of providing access, and define a methodology to calculate the gap and a methodology to calculate the investments in maintenance and asset replacement.

C.2.1. Goal definition according to the relevant SDG

The relevant goal is SDG-6, and more specifically target 6.2, which states: “By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations”. Consequently, the goal to close the gap is that 100% of rural and urban households have access to safely managed sanitation services by 2030.

C.2.2. Information sources for indicators on access to sanitation

For sanitation services coverage in LAC we used the information available at JMP, which reports access rates under the basic and safe standards.

C.2.3. Unit costs

To obtain the unit costs of providing access to sanitation under the different standards of service we used information from several sources. We had access to several IDB projects and to the expert advice of specialists in the field. These were the main projects we used as information sources: Peru’s National Infrastructure Plan, by Bonifaz *et al*. (2019); Dominican Republic’s National Infrastructure Plan (to be published); the estimation of the infrastructure gap for the countries of the Andean Community; and the analysis of specialists based on operative projects in Panama and Paraguay.

Additionally, we used information on unit costs reported by Hutton and Varughese (2016). This study was conducted by the World Bank as a background paper for its “Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet” report. That report details unit costs per country of different solutions which can provide access to drinking water and sanitation services under several quality standards and includes information for 24 countries in LAC.

Table A.3. summarizes the costs we gathered, expressed in dollars per person served. These values are related to two of the standards set by the JMP: a standard defined as basic, meaning access to improved installations that are not shared with other households; and a standard defined as safe, meaning the access to sanitation services with improved installations which are not shared with other households and where excreta are either safely deposited *in situ* or led outside the household for their treatment. The values used to calculate the gap presented in this study are highlighted.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified

Table A.3. *Unit costs per inhabitant of providing access to sanitation services by connection standard (USD)*

SECTOR	PERU STUDY	CAN STUDY			
		COLOMBIA	ECUADOR	PERU	TOTAL
SANITATION					
Basic Urban Sanitation	847.88	359	268.83	1.372	847.88
Basic Rural Sanitation	1,244.85	359	599.19	1.372	1,244.85
Safe Urban Sanitation	2,222.91				2,222.91
Safe Rural Sanitation	2,222.91				

SECTOR	DOMINICAN REPUBLIC STUDY	INFORMATION FROM WSA SPECIALISTS		HUTTON AND VARUGHESE (2016)	
		PANAMA	PARAGUAY	LAC AVERAGE	LAC MEDIAN
SANITATION					
Basic Urban Sanitation	305	1.530		262.12	243.70
Basic Rural Sanitation	524			96.83	96.80
Safe Urban Sanitation	735		160	458.88	370.10
Safe Rural Sanitation	735			309.39	181.50

C.2.4. Methodology for the estimation of the infrastructure gap in safely managed sanitation

The methodology to calculate and value the infrastructure gap to guarantee access to safely managed sanitation was the following:

- First, we determined the number of households per country, both in rural and urban settings, which had access to basic sanitation and to safely managed sanitation, according to the JMP's definitions. We additionally estimated the number of households which did not have a sanitation service of a standard that reached the level of either the basic or safely managed standards.

- Second, we determined the expected increase of the number of households up to 2030, according to the expected population growth. This estimation was done by dividing the expected increase in population by the inhabitants per household for 2018 by geographical area (urban / rural).

- The third step was to multiply the households requiring access by the corresponding unit cost. We used the cost of a new safely managed sanitation connection for both the new households resulting from demographic growth and for those which did not have access to basic sanitation. For the households which only had access to basic sanitation services, we used the unit cost of an upgrade, which we obtained as the difference between the cost of a safely managed sanitation connection and the cost of a basic sanitation connection.

As we mentioned in this study, there is a relevant methodological clarification for the countries for which we had no information on sanitation service coverage by quality standards (basic or safe); in this case we made two alternative assumptions:

1. Assuming that all households with access to sanitation services had it with the safely managed standard. This assumption underestimates the real gap, and, thus, the investment amounts obtained with it are to be considered minimum indispensable bounds.

2. Assuming that all households with access to sanitation services had it with the basic standard. This assumption overestimates the real gap, and, thus, the investment amounts obtained with it are to be considered maximum levels.

As in the water sector, our knowledge of the sector's reality leads us to think that it is probably closer to the truth to assume that, in the countries lacking information, households that report access do not have access to safely managed sanitation but rather only basic access; consequently, they would require additional investments.

C.2.5. Methodology for the estimation of maintenance and asset replacement costs

To estimate the investment for the maintenance of sanitation services in an optimal level we had to estimate the value of the existing infrastructure cost. Given the available information, we multiplied the number of households depending on their connection category (basic sanitation, safe sanitation), both urban and rural, by the previously determined unit costs. Additionally, we used linear depreciation over the value of the stock of infrastructure to represent the loss of the assets' value as a result of their use in time.

The annual investments necessary to cover the replacement of assets are fixed as annual amounts that allow the replacement of the net value of existing assets considering a lifespan of 30 years. The infrastructure maintenance cost, meanwhile, was estimated using a 2% annual coefficient on the estimated value of total assets, including new investments, based on the estimates of maintenance costs reported by the specialists of the Water and Sanitation Division in Panama.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified.

C.3. Calculation of the infrastructure gap affecting wastewater treatment

To calculate the infrastructure gap and the investments necessary to guarantee wastewater treatment we had to set the goal to fulfill according to the relevant SDG, collect information relative to the existing level of wastewater treatment, determine the unit costs, and determine the methodology to calculate the gap.

C.3.1. Goal definition according to the relevant SDG

In this case, the relevant goal is SDG-6, and specifically target 6.3, which states: "By 2030, improve water quality (...) halving the proportion of untreated wastewater (...)". However, to estimate the infrastructure gap we assumed that all the wastewater generated by urban populations in LAC should receive treatment at a water treatment plant by 2030. This aim goes beyond target 6.3; however, it is consistent with target 6.1, which implies providing universal access to safely managed sanitation, and it contributes to fulfilling other SDGs, such as those connected with conservation of marine life (SDG-14), the sustainability of cities (SDG-11), and actions related to climate change (SDG-13).

C.3.2. Information sources for indicators on wastewater treatment

For the baseline of wastewater treatment in LAC we used the information reported by the World Health Organization in the SDG-6.3.1 tracking page. It is worth mentioning that we verified all national files to obtain each country's percentage of wastewater treated in plants (excluding septic tanks). Finally, assuming that all treatment in plants is set in urban areas, we calculated the percentage of urban wastewater treatment.

We have information on wastewater treatment levels for the following countries: Argentina, Brazil, Chile, Colombia, Ecuador, El Salvador, Mexico, and Peru. There is no reasonable criterion to assume wastewater treatment percentages in countries without information; in this sense, this part of the estimation underestimates the gap in wastewater treatment. However, the impact of this limitation is reasonably small, since countries included in the calculation account for 80% of LAC's population in 2030.

C.3.3. Unit costs

To obtain the unit costs to provide wastewater treatment, we collected cost information, in dollars per inhabitant, for different technologies. A review of the relevant literature allows us to set five types of technology, ordered by their average cost: i) lagoons, ii) UASB[32], iii) primary treatment, iv) trickling filters, and v) activated sludge.

We gathered information on unit costs of each technology from the following document: "Modelo de Costos para el Tratamiento de las Aguas Residuales en la Región" ("A Cost Model for Wastewater Treatment in the Region"), published by Salas *et al*. (2007). These costs were updated considering an annual inflation of 2%.

We also reviewed Peru's "National Sanitation Plan, 2017-2021" and the "National Level Sanitation Sector Investment Plan, 2014-2021", both of which include a unit cost that is not broken down by technology, and which is higher than the amount used in this study.

Table A.4. *Unit costs per inhabitant of building treatment plants, by technology (USD per inhabitant)*

	COLOMBIA STUDY (SALAS, ZAPATA Y GUERRERO)					
	2007			UPDATED (2021)		
SECTOR	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
WASTEWATER TREATMENT						
Lagoons	10	30	20	13.2	39.6	26.4
Anaerobic reactor (UASB)	20	40	30	26.4	52.8	39.6
Primary treatment	20	30	25	26.4	39.6	33.0
Trickling filter	30	60	45	39.6	79.2	59.4
Activated sludge	40	120	80	52.8	158.3	105.6

Source: Salas, Zapata y Guerrero (2007). Authors' elaboration.

Additionally, to calculate the infrastructure gap in wastewater treatment, we assumed that each of the technologies would contribute equally to closing the gap. However, both the unit costs and the participation of each technology on the technology mix are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when these assumptions are modified.

32 Upflow Anaerobic Sludge Blanket.

C.3.4. Methodology for the estimation of the infrastructure gap in wastewater treatment

The methodology to calculate and value the infrastructure gap to guarantee wastewater treatment was the following:

- First, given the 2018 population, we determined the number of people, in urban settings, whose wastewater is not currently treated. That was calculated by difference, because we have the percentage of the urban population with wastewater treatment.
- To calculate the current infrastructure gap in wastewater treatment, we multiplied the urban population without treatment by the average unit cost (in USD per inhabitant), considering that each technology contributes equally to closing the treatment gap.
- Finally, to calculate the necessary investment to treat the wastewater that will be generated as a consequence of population growth, we multiplied the average unit cost of treatment by the urban population increase between 2018 and 2030.

This calculation was made for the 8 countries for which there is information available on treatment level, which account for 80% of LAC's population by 2030. Additionally, we have to mention that the calculation of these gaps only includes the increase in demand due to population growth. However, treatment will have to include both residential wastewater and non-residential wastewater which come with the aforementioned demographic growth. Hence, this reference amount of the infrastructure gap in wastewater treatment must be thought of as a minimum bound.

D.

CALCULATION OF THE INFRASTRUCTURE GAP AFFECTING TELECOMMUNICATIONS SERVICES

We estimated the infrastructure gap considering two dimensions for the telecommunications sector: guaranteeing access to fixed broadband services and guaranteeing access to mobile telecommunications.

D.1. Calculation of the infrastructure gap affecting telecommunication services

To calculate the infrastructure gap and the investments needed to guarantee access to telecommunication services we had to set the goal to achieve according to the relevant SDG, collect information on the level of access to telecommunication services under its different technologies and standards of service, determine the relevant unit costs, and determine the methodology to calculate the gap and the investment in maintenance and asset replacement.

D.1.1. Goal definition according to the relevant SDG

The relevant goal is SDG-9 and, more specifically target 9.c which states: "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020". In this case, and since the SDGs do not present a quantitative goal, this study defines the gap in relative terms to the access provided in the most advanced countries with two technologies: fixed broadband and mobile Internet access under a 4G standard.

D.1.2. Information sources for indicators on access to fixed broadband and 3G and 4G mobile telecommunication services

The information on coverage comes from two sources: for fixed broadband service coverage, we used the indicator of quantity of fixed broadband connections per 100 inhabitants reported in the World Bank's World Development Indicators (WDI); whereas for 3G and 4G mobile networks, the data was gathered from the International Telecommunication Union databases, which report coverage for both services for 2018.

D.1.3. Unit costs

Obtaining the unit costs of providing access to fixed broadband services and 3G and 4G mobile communications technologies is not simple. The evidence from implemented projects and projects under implementation shows a high dispersion in unit costs (in dollars per inhabitant), attributable to the types of projects (urban or rural, new or extension of existing networks, *brownfield* or *greenfield*), among other factors.

For the fixed broadband service, we used different unit costs by country (see Table A.5). These were provided by the Connectivity, Markets, and Finance (CMF) Division of the Institutions for Development Sector (IFD) at the IDB, and support the investment gap estimates included in the Annual Report of the Broadband Development Index (García et al. 2021) published by the IDB.

Table A.5. *Unit costs for fixed broadband service access (USD per inhabitant)*

COUNTRY	UNIT COST	COUNTRY	UNIT COST
Argentina	504	Guyana	682
Bahamas	396	Haiti	102
Barbados	39	Honduras	296
Belize	500	Jamaica	152
Bolivia	560	Mexico	331
Brazil	450	Nicaragua	355
Chile	450	Panama	349
Colombia	378	Paraguay	495
Costa Rica	279	Peru	451
Cuba	339	Dominican Republic	178
Ecuador	324	Suriname	690
El Salvador	135	Trinidad & Tobago	152
Grenada	339	Uruguay	480
Guatemala	217	Venezuela	417

Source: Connectivity, Markets, and Finance (CMF) Division of the Institutions for Development Sector (IFD) - IDB.

For the mobile Internet service with 4G technology, we estimated a unit cost using two sources of information. The first source is Mexico's "National-level design, construction, modernization, equipment, installation, operation, and maintenance for the commercialization of the shared telecommunications network" project, with an estimated investment of USD 7 billion with a unit cost of around USD 58 per inhabitant[33]. The second is Peru's National Infrastructure Plan, which uses a unit cost of around USD 2,000 per inhabitant for 4G technology. Considering the urban (81%) – rural (19%) ratio, the weighted unit cost average is USD 427 per inhabitant. Accounting for the proportion between 3G and 4G unit costs in the National Infrastructure Plan, the cost of 3G for calculating the gap is USD 171. Finally, the cost of upgrading from 3G to 4G is calculated as the difference of the respective unit costs, which is USD 256 per inhabitant.

33 https://www.proyectosmexico.gob.mx/proyecto_inversion/red-publica-compartida-de-telecomunicaciones/ [accessed September, 14th, 2021.]

Table A.6. *Unit costs of access to mobile telecommunications services (USD per inhabitant)*

COST	VALUE
Cost per inhabitant to provide mobile telecommunication services under 3G standard	171
Cost per inhabitant to provide mobile telecommunication services under 4G standard	427
Cost per inhabitant to upgrade mobile telecommunication services from 3G to 4G standard	256

Source: Connectivity, Markets, and Finance (CMF) Division of the Institutions for Development Sector (IFD) - IDB.

D.1.4. Methodology for the estimation of the infrastructure gap in telecommunications

The methodology to calculate the infrastructure gap in fixed broadband services was the following:

1. First, we determined the differential between the number of inhabitants per country which had access to fixed broadband services and the number of inhabitants necessary to achieve the coverage levels of the benchmark countries (the median of OECD countries as set in the Dominican Republic infrastructure gaps study). For those countries where access levels were higher than those of the benchmark countries, it was considered that no short term investments were necessary to provide more coverage.

2. Second, as a result of the expected population growth to 2030, we calculated the number of new inhabitants which will require access to fixed broadband services to achieve the coverage of the benchmark countries. If a given country's access level were higher than those of the benchmark countries, we estimated the number of inhabitants to whom access should be provided to keep the current coverage levels of fixed broadband services.

3. Third, we multiplied the number of inhabitants that require access to fixed broadband services as estimated in (1) and (2) by the corresponding unit cost.

The methodology to calculate the infrastructure gap in mobile telecommunications service under 4G standard was as follows:

1. First, we determined the number of inhabitants per country which had access to telecommunications under 3G and 4G standards.

2. Second, as a result of the expected population growth to 2030, we calculated the number of inhabitants which will require access to 4G telecommunications services to achieve the coverage level of the benchmark countries (the median of OECD countries as set in the Dominican Republic infrastructure gaps study).

3. Third, we subtracted the number of inhabitants which already had access to 4G communications networks in 2020 to the number determined in (2).

4. Considering that the standard selected to provide access is 4G, we performed the following calculations to compute the gap: (a) we used the unit cost of the upgrade reported in the prior section for inhabitants who had 3G network coverage but not 4G,; (b) we used the unit cost of providing 4G service for inhabitants who currently are not connected and for projected inhabitants.

D.1.5. Methodology for the estimation of maintenance and asset replacement costs

To estimate the investment for the maintenance of telecommunication services in an optimal level, we had to estimate the value of the existing infrastructure stock. Considering available information, we multiplied the number of inhabitants covered by the different services (fixed broadband, 3G telecommunications, and 4G telecommunications) by the previously defined unit costs. Additionally, we used linear depreciation over the value of the stock of infrastructure to represent the loss of the assets' value as a result of their use in time.

The annual investment amounts needed to cover asset replacement are annual payments which allow replacing the net value of existing assets. Due to the rapid obsolescence of some assets in this sector, we used a 15 year asset lifespan. The infrastructure maintenance cost, meanwhile, was estimated using a 2% annual coefficient on the estimated value of total assets, including new investments.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified.

E.

CALCULATION OF THE INFRASTRUCTURE GAP AFFECTING TRANSPORTATION SERVICES

This study considered three dimensions to estimate the infrastructure gap in the transportation sector: guaranteeing rural access to the road network, providing adequate logistics infrastructure, and guaranteeing access to adequate and sustainable mass urban transportation.

E.1. Calculation of the infrastructure gap affecting rural access to the road network

To calculate the infrastructure gap and the investments to guarantee rural access to the road network, we had to set the goal to fulfill in line with the relevant SDG, collect information regarding the rural population's access to a road network, define unit costs, and determine the methodology to calculate the gap and investments in maintenance and asset replacement.

E.1.1. Goal definition according to the relevant SDG

The relevant goal is SDG-9, and more specifically target 9.1. which states: "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all." A key indicator in this target is the proportion of the rural population who live within 2 kilometers of an all-season road, as measured by the Rural Accessibility Index (RAI).

For this study, the goal we set is to guarantee the transitability during the whole year of the existing tertiary road network and to increase its coverage up to 2030 in line with its historical expansion.

E.1.2. Information sources to determine the extension and transitability of primary, secondary, and tertiary road networks

The main source to determine the extension of the primary, secondary, and tertiary roads were the IRF's databases. These databases supply reasonably updated (2016 onwards) information on the extension and paving percentage of the road networks of 18 of the region's countries. The databases do not have information on the conditions of the roads nor on their transitability throughout the year.

Additionally, we conducted a process of consultations with the IDB's Transport Division specialists in each of the region's countries to validate, update, and expand the available information, especially regarding the conditions and transitability of the road networks. When the information provided by the specialists improved the basic information obtained from the IRF, their observations were given priority and were integrated to the preexisting database.

E.1.3. Unit costs

The construction and maintenance unit costs for the road networks were obtained from the World Bank's ROCKS database. This database has unit costs for construction, routine maintenance, and periodic maintenance with a breakdown by the world's regions and by type of roadway. The information included in this database comes from the compilation of the results of more than 4,800 documents linked to road network construction and maintenance projects which have been financed by multilateral development banks (World Bank, Asian Development Bank, African Development Bank) in more than 89 low and medium-income countries. The unit costs are presented in Table A.7; for this study we used the values for LAC.

Table A.7. *Construction and maintenance unit costs by roadway type and region (in USD per km)*

REGION	UPGRADE FROM 2 TO 4 PAVED LANES	PAVING 2 LANES	UPGRADE TO PAVED	GRAVEL	ROUTINE MAINTENANCE (2 LANE PAVED)	ROUTINE MAINTENANCE (GRAVEL)	PERIODIC MAINTENANCE (2 LANE PAVED)	PERIODIC MAINTENANCE (GRAVEL)
South Asia	3,570,000	843,000	420,000	19,000	4,000	2,000	23,000	15,000
Sub-Saharan Africa	3,800,000	933,000	616,000	23,000	4,000	2,000	23,000	15,000
Middle East and North Africa	2,333,000	665,000	413,000	19,000	4,000	2,000	23,000	15,000
East of Asia and the Pacific	4,597,000	1,200,000	703,000	39,000	4,000	2,000	23,000	15,000
Latin America and the Caribbean	4,154,000	1,395,000	695,000	37,000	4,000	2,000	23,000	15,000

Source: Mikou *et al*., 2019. Authors' elaboration.

As we do not have information on routine and periodic maintenance costs for 4-lane paved roads, we have assumed that they are twice the incurred cost for 2-lane paved roads.

E.1.4. Methodology for the estimation of the infrastructure gap in rural access to the road network

In order to estimate the gap in rural access to the road network, we made several calculations and assumptions depending on the information about conditions and transitability.

For countries without information regarding the condition and transitability of the roads, the methodology was as follows:

- Since we do have information on the total network extension and the percentage that is paved, we estimated the number of paved kilometers for each of the countries' road networks. Since most of the paved roads are part of primary or secondary networks, we assume that they did not require interventions to guarantee their transitability throughout the year.
- Subtracting, we determined the kilometers of unpaved roads. The following assumptions were made for the estimation of the infrastructure gap: i) 30% of the unpaved network did not require interventions to guarantee its transitability; ii) 40% of the unpaved network required urgent periodic maintenance to guarantee its transitability; iii) 30% of the unpaved network required reconstruction to guarantee its transitability throughout the year[34].
- Finally, we calculated the cost of expanding the road networks in line with their historic growth; this includes a 10% expansion of its total kilometers up to 2030; paving (2 lanes) of 10% of the existing unpaved network up to 2030; and the upgrade of 5% of the paved network (2 lanes) to highways (4-lane paved roads).
- These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when the assumptions are modified.

34 We have to remark that the World Bank exercise assumes that a high percentage of the unpaved network (especially the length of roads belonging to the tertiary network) does not guarantee transitability according to the standards of the RAI indicator. This assumption is verified; when we compare countries with RAI measurement, the results are close to the expected results considering only primary and secondary networks. Since the assumption used in this exercise implies that at least 30% of the tertiary network (which in LAC is almost completely unpaved) does not require interventions, these estimates should be considered as a lower bound.

For countries for which we did have information regarding the condition and transitability of the roads, the methodology was as follows:

- If the condition of the road was reported as good / very good, we considered no interventions are necessary.
- If the condition of the road was reported as fair, we considered that urgent periodic maintenance was needed.
- If the condition of the road was reported as bad / very bad, we considered the cost of reconstruction.
- The criteria for expanding the road network were kept constant relative to the group of countries for which we did not have information on the condition of the road network.

E.1.5. Methodology for the estimation of maintenance and asset replacement costs

To estimate the investment needed for the maintenance of the road network in optimal conditions we had to estimate the value of the existing infrastructure stock, using the unit costs and each country's information on network extension by road type. We then used linear depreciation over the value of the stock of infrastructure to represent the loss of the assets' value as a result of their use in time.

Additionally, we calculated the number of kilometers of each type of road that need to be constructed each year to fulfill the goal up to 2030. We can thus project the total annual extension of the road network and then use the maintenance unit costs reported by the World Bank's ROCKS database. We assumed that routine maintenance is performed annually; and that periodic maintenance is performed midway through the asset's lifespan.

The annual investments necessary to cover the replacement of assets are fixed as annual amounts that allow the replacement of the net value of existing assets considering a lifespan of 30 years.

These values are model parameters and it is possible to do a sensitivity analysis to determine the change in estimates when assumptions are modified.

E.2. Calculation of the infrastructure gap to provide adequate logistics

In order to provide adequate logistics, we considered the airport infrastructure gap. We identified relevant studies that provide specific information on these investment needs. Additionally, as a reference, the document includes a box with information on CAF's estimates of the region's ports infrastructure gap.

E.2.1. Goal definition according to the relevant SDG

The relevant goal is SDG-9, which states: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". And more specifically, target 9.1, which aims to: "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all." Although there is no explicit quantitative goal up to 2030, we focus on airport investments to guarantee connectivity for the countries of LAC.

E.2.2. Relevant studies on the logistics gap

The information relative to the airport gap presented in this document is based on Brichetti *et al*. (2021), which estimated the investments to guarantee access to airport infrastructure for urban centers in the region with at least 100,000 inhabitants. As far as the port gap is concerned, this study includes a box based on CAF (2016), which estimated the potential demands for port logistics services and estimated the investments necessary to meet them. The estimates include both the expansion of the capacity to handle containers needed to meet the growth in demand, and dredging activities to deepen access to port nodes.

E.3. Calculation of the infrastructure gap for urban mass transit

To calculate the infrastructure gap for urban mass transit, we had to set a goal to fulfill in terms of the relevant SDG, collect information on the available urban mobility infrastructure, set the relevant unit costs, and define a methodology for the calculation.

E.3.1. Goal definition according to the relevant SDG

The relevant goal is SDG-11, and more specifically target 11.2, which states: "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons". Since it does not present a specific quantitative target, this study calculates the infrastructure gap to provide urban mobility for cities with at least 500,000 inhabitants by comparing them to the standard of the cities with the best performance in LAC.

E.3.2. Information sources on the current mass transit design

The information on the current design of mass transit systems in LAC –Bus Rapid Transit, suburban railroads, and underground networks– has been obtained from several information sources.

The main source for BRT systems and high capacity motor transportation systems has been BRTData. The construction of the platform and the gathering of information are the result of a partnership between the members of BRT + CoE and the Institute for Transportation and Development Policy (ITDP). Currently, BRTData is managed and updated by WRI Brazil Ross Center for Sustainable Cities. The initial versions of the database had the support of the International Energy Agency (IEA) and the Latin American Association of Integrated Transport and BRT Systems (SIBRT), now SIMUS. The available information was complemented by data provided by the IDB's Transport Division.

The information on suburban railroads and underground systems has been gathered from individual sources for each of the cities of the study, using governmental and private sources provided by the IDB's Transport Division.

Table A.8. *details the cities of the region included in this document with information relative to their mass transport systems.*

COUNTRY	CITY	COUNTRY	CITY
Argentina	Buenos Aires	Colombia	Cartagena
Argentina	Cordoba	Colombia	Medellin
Brazil	Belem	Colombia	Pereira
Brazil	Belo Horizonte	Costa Rica	San Jose (metro area)
Brazil	Brasilia	Dominican Republic	Santo Domingo
Brazil	Campinas	Ecuador	Guayaquil
Brazil	Curitiba	Ecuador	Quito
Brazil	Fortaleza	El Salvador	San Salvador (metro area)
Brazil	Goiania	Guatemala	Guatemala
Brazil	Guarulhos	Mexico	Acapulco
Brazil	Londrina	Mexico	Chihuahua
Brazil	Maceio	Mexico	Guadalajara
Brazil	Natal	Mexico	Guadalupe
Brazil	Porto Alegre	Mexico	Ciudad Juarez
Brazil	Recife	Mexico	Leon
Brazil	Rio de Janeiro	Mexico	Mexico City (Metro area)
Brazil	Salvador	Mexico	Monterrey
Brazil	Sao Paulo	Mexico	Puebla
Brazil	Teresina	Panama	Panama
Brazil	Uberlandia	Peru	Lima
Chile	Santiago	Uruguay	Montevideo
Colombia	Barranquilla	Venezuela	Barquisimeto
Colombia	Bogota	Venezuela	Caracas
Colombia	Bucaramanga	Venezuela	Maracaibo
Colombia	Cali	Venezuela	Valencia

Source: authors' elaboration.

E.3.3. Unit costs

The unit costs gathered to calculate the infrastructure gap in urban mobility are the construction costs of one kilometer of: (i) new exclusive lanes for BRT; (ii) sub-urban railways; and (iii) underground railways.

To estimate the construction costs for new BRT lanes, the specialists at IDB's Transport Division gathered information on the expansion projects of BRT systems considered relevant. They considered completed and in development projects within the region and in other countries in the last decade. Table A.9. summarizes the costs of each of the projects considered. To calculate the gap, we used USD 11.8 million per new BRT kilometer, the average value of all the projects considered.

Table A.9. *Construction costs per kilometer of BRT projects considered for the estimates*

PROJECT	COUNTRY	USD MILLION / KM
Transmilenio 1	Colombia	17.17
Transmilenio 2	Colombia	33.04
Línea Verde	Brazil	7.79
TransOeste	Brazil	14.45
TransCarioca	Brazil	14.72
Antonio Carlos	Brazil	24.62
Cleveland HealthLine	U.S.A.	18.88
Orange Line	U.S.A.	16.33
Ahmedabad Jan Marg	India	3.00
Mexico City	Mexico	6.25
Johannesburg	South Africa	1.49
Cape Town	South Africa	13.05
Tshwane	South Africa	1.21
TransJakarta L2, L3	Indonesia	2.45
Guangzhou	China	6.44
Lanzhou	China	7.71
Yichang BRT	China	12.58
Average		**11.83**

Source: IDB Transport Division.

We based our estimates of the construction cost of one kilometer of a new railway on the cost of recent projects in the region in different stages of development (Mexico City train, San Jose's electric train in Costa Rica, Regiotram Colombia); on average costs of completed projects in the U.S. and Europe; and also considering the costs reported in the Mass Transit Option manual, a joint effort of the Deutsche Gesellscharft Technische Zusammernarbeit (GTZ) and the Institute for Transportation and Development Policy (ITDP). In order to estimate the gap, we used USD 36.5 million per new kilometer of suburban railway, the value suggested in the report.

To estimate the construction cost of one kilometer of underground railway, the specialists of the IDB's Transport Division gathered information of the expansion projects of underground systems considered relevant. They considered completed and in development projects within the region and in other countries in the last decade. Table A.10. summarizes the results of the costs per project considered. Towards the calculation of the gap, we used the average value of the projects under consideration: USD 110.2 million per kilometer of new underground railway.

Table A.10. *Construction cost of one kilometer of underground railway in projects considered for the estimation*

PROJECT	USD MILLION / KM	PROJECT	USD MILLION / KM
Copenhagen	102.05	Atlanta	128.66
Madrid (expansion)	39.04	Baltimore	215.65
Toulouse	89.04	Los Angeles	192.40
Toulouse (expansion)	118.57	Atlanta (North expansion)	185.53
Marseille (L1 y L2)	86.40	San Francisco	159.94
Lille	81.87	Singapore	79.68
Lyon (LD)	116.23	Seoul	96.20
Marseille (expansion)	100.59	Calcutta	87.57
Toulouse	92.40	Mexico City (LB)	64.04
London	92.25	Caracas (L3)	143.86
Vienna	137.72	Santiago (L5 expansion)	104.97
Berlin	129.09	Quito (L1 M)	85.80
Hannover	23.54	Panama (L1 M)	135.61
Hannover (expansion)	83.19	Santo Domingo (L1 M)	69.63
Torino	104.83	Lima (L2 M)	129.11
Washington, DC	167.11	Santiago (L3 M)	83.98
Average			**110.2**

Source: IDB Transport Division.

E.3.4. Methodology for the estimation of the infrastructure gap in urban mass transportation

To calculate the infrastructure gap in urban mobility we made several calculations and assumptions.

First, we identified all the cities of the region with populations of at least 500,000 inhabitants for which we had reliable information regarding the size of their mass transportation systems (both BRT and railroad systems). Then we divided the cities in two subgroups: cities with populations of 0.5 to 5 million inhabitants (Tier 1) and cities with more than 5 million inhabitants (Tier 2).

We then determined the number of kilometers of mass transportation networks per million inhabitants for each of the cities we identified. Having calculated that indicator, we then set benchmarks for each subgroup of cities (Tier 1 and 2). For the cities between 0.5 and 5 million inhabitants (Tier 1) we used as a benchmark the average number of kilometers of public transportation per inhabitant of Cordoba (Argentina), and Natal, Porto Alegre and Recife (Brazil), which is 59.9 km per million inhabitants. For cities of more than 5 million inhabitants (Tier 2), the benchmark was the average for Buenos Aires, Rio de Janeiro, and Santiago, which is 55.4 kilometers per million inhabitants.

Once we had those benchmark numbers, we estimated the number of kilometers of mass transportation infrastructure to be built to achieve similar coverage levels for all the cities of the region. To this end we used United Nations information on current population and projections towards 2030.

Additionally, we estimated the population in the region living in cities of at least 500,000 inhabitants which were not included in the sample of cities with mass transportation systems. In this line, we assumed that those cities do not have mass transportation systems. In this case, the comparison vis a vis the benchmarks was made assuming that the coverage levels attainable within the period are a fifth of those of the cities included in the sample. This is a conservative assumption, since it includes cities not included in the sample which do not have the population density to sustain efficient mass transportation systems. Having said this, this assumption is a parameter of the estimation and can thus be modified.

Once we determined the kilometers of mass transportation networks to be built to close the gap, we devised two scenarios to quantify the investments:

- First we considered a scenario focused on cost-efficient investments in mass transportation, i.e. mainly based in BRT solutions. In this scenario, the gap in mass transportation kilometers was closed by building 75% of those kilometers with BRT lanes, 15% with suburban railways, and 10% with underground railways. The investment cost was obtained by multiplying the kilometers required for each solution by the unit costs we discussed above. This is the scenario reported on our document (USD 225 billion).

- Second, we devised a scenario focused on the capacity and quality of the investments in mass transportation, based mainly on railroad solutions. In this scenario, the gap in mass transportation kilometers was closed by building 30% of those kilometers with BRT lanes, 20% with suburban railways, and 50% with underground railways. The investment cost was obtained by multiplying the kilometers required for each solution by the unit costs we discussed above. This scenario entails a significantly higher investment need of USD 586 billion.

F.

CONSOLIDATED RESULTS AND AVAILABILITY OF COUNTRY-SPECIFIC INFORMATION

As we have mentioned, the estimates have been made based on the information available for the different sectors in each country. Table A.11. summarizes the availability of information to make the calculations of each infrastructure gap in each of the countries of the region; and Table A.12. presents the disaggregated results of the investment gap in each sector in each country.

Table A.11. *Availability of information for the calculation of the gap per sector and country*

COUNTRY	WATER AND SANITATION			ELECTRICITY		TRANSPORTATION			TELECOMUNICATIONS		TOTAL INVESTMENT
	WATER ACCESS	SANITATION ACCESS	WASTEWATER TREATMENT	ACCESS	GENERATION AND TRANSMISSION	ROAD	AIRPORT	URBAN MASS TRANSPORT	FIXED BROADBAND	4G	
Argentina	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Bahamas	🟢	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🟢	🟢
Barbados	🟢	🟢	🔴	🟢	🔴	🔴	🔴	🔴	🟢	🟢	🟢
Belize	🟢	🟢	🔴	🟢	🟢	🔴	🔴	🔴	🟢	🟢	🟢
Bolivia	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Brazil	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Chile	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Colombia	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Costa Rica	🟢	🟢	🔴	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢
Ecuador	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
El Salvador	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢
Guatemala	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Guyana	🟢	🟢	🔴	🟢	🟢	🔴	🔴	🔴	🟢	🟢	🟢
Haiti	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢
Honduras	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Jamaica	🟢	🟢	🔴	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢
Mexico	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Nicaragua	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Panama	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Paraguay	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Peru	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Dominican Republic	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Suriname	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢
Trinidad & Tobago	🟢	🟢	🔴	🟢	🟢	🔴	🔴	🟢	🟢	🟢	🟢
Uruguay	🟢	🟢	🔴	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢
Venezuela	🟢	🟢	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢

🟢 **With available information for the infrastructure gap estimation**

🔴 **Without available information for the infrastructure gap estimation**

Table A.12. *Consolidated results of the infrastructure gap per sector and country (million USD)*

COUNTRY	WATER AND SANITATION			ELECTRICITY		TRANSPORTATION			TELECOMUNICATIONS		TOTAL INVESTMENT
	WATER ACCESS	SANITATION ACCESS	WASTEWATER TREATMENT	ACCESS	GENERATION AND TRANSMISSION	ROAD	AIRPORT	URBAN MASS TRANSPORT	FIXED BROADBAND	4G	
Argentina	12,296	17,401	2,238	4,743	74,751	67,396	420	5,803	5,849	13,507	204,404
Bahamas	124	159	-	-	-	-	-	-	44	114	441
Barbados	82	101	-	74	-	-	-	-	22	62	342
Belize	164	197	-	59	1,197	-	-	-	84	195	1,895
Bolivia	4,248	5,939	-	1,998	5,051	28,523	70	2,173	2,848	4,422	55,273
Brazil	36,723	59,971	7,549	32,627	157,305	333,475	4,410	80,442	28,113	60,500	801,115
Chile	2,107	3,036	295	2,213	48,281	22,507	670	2,079	2,259	5,715	89,164
Colombia	8,889	18,080	2,009	6,265	34,800	53,627	510	25,741	6,182	12,941	169,044
Costa Rica	804	2,081	-	708	4,535	11,038	-	3,562	465	1,541	24,733
Ecuador	3,705	5,903	554	2,200	21,024	23,202	370	5,330	2,173	7,489	71,950
El Salvador	2,178	3,252	179	1,126	5,838	-	600	3,380	393	3,466	20,413
Guatemala	5,813	12,233	-	2,959	6,257	5,312	210	4,052	1,901	9,462	48,199
Guyana	298	348	-	190	532	-	-	-	175	292	1,836
Haiti	5,305	8,205	-	6,580	179	-	220	1,237	554	6,290	28,571
Honduras	4,119	4,582	-	1,633	3,759	3,808	140	1,046	1,362	4,937	25,387
Jamaica	1,034	1,205	-	490	1,688	5,776	-	263	191	1,217	11,864
Mexico	27,590	35,030	3,001	14,120	84,966	119,448	4,060	51,227	14,495	39,808	393,745
Nicaragua	1,784	3,335	-	696	2,194	5,309	600	474	1,050	3,204	18,647
Panama	1,614	2,148	-	967	4,712	5,110	70	1,549	558	2,282	19,010
Paraguay	1,858	2,356	-	936	3,071	8,285	140	1,488	1,508	2,954	22,596
Peru	7,936	11,943	1,022	3,674	13,680	35,766	730	15,107	5,837	14,422	110,115
Dominican Republic	3,617	4,922	-	1,478	7,149	6,351	70	4,459	844	3,286	32,175
Suriname	190	256	-	162	116	748	70	-	122	291	1,955
Trinidad & Tobago	436	497	-	123	1,319	-	-	243	85	415	3,117
Uruguay	382	1,215	-	417	5,141	2,832	-	2,112	223	840	13,160
Venezuela	9,363	9,986	-	3,101	-	-	1,840	10,609	4,912	11,772	51,583
Total (Latin America and the Caribbean)	**142,661**	**214,381**	**16,848**	**89,538**	**487,545**	**738,512**	**15,200**	**222,376**	**82,246**	**211,428**	**2.220,736**

IDB