



HOW EMERGING TECHNOLOGIES AND SOLUTIONS IN FIXED CONNECTIVITY CONTRIBUTE TO CLIMATE MITIGATION AND ADAPTATION

REPORT

Deloitte.

 **IDB | Invest**

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Preface

At IDB Invest, we recognize that the twin challenges of climate change and digital Connectivity and inclusion are not only defining our era but are deeply interconnected. As Latin America and the Caribbean (LAC) face increasing climate vulnerability, the role of digital infrastructure—particularly fixed connectivity—has become central to both climate mitigation and adaptation strategies.

This report, "How Emerging Technologies and Solutions in Fixed Connectivity Contribute to Climate Mitigation and Adaptation," was commissioned to explore how the digital infrastructure sector can accelerate the region's transition to a low-carbon, climate-resilient future. It provides a comprehensive analysis of how fixed broadband infrastructure can reduce its own emissions footprint while enabling broader decarbonization across industries such as energy, transport, and manufacturing.

For IDB Invest, this work is part of our commitment to supporting sustainable, resilient and inclusive development through innovation and investments in digital infrastructure and services. The findings highlight actionable pathways for telecom operators, policymakers, and investors to align digital expansion with climate goals—through renewable energy integration, energy-efficient technologies, circular economy practices, and climate-resilient infrastructure.

We believe this report will serve as a valuable resource for stakeholders across the region, offering a roadmap to harness the power of connectivity for a greener, more resilient future. It reflects our conviction that the digital economy, when guided by sustainability, can be a powerful force for climate action and economic opportunity.

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Introduction

Broadband Connectivity and Digital Technologies

Broadband Connectivity and Digital Technologies stands at a critical crossroads in the fight against climate change. As the world moves toward decarbonization, the ICT industry must accelerate its transition to more sustainable models. Currently, the sector accounts for approximately **2% of global greenhouse gas (GHG) emissions**, but its impact extends further: **it has the potential to enable up to a 15% reduction in emissions across other industries**, such as energy, transportation, and manufacturing, through digitalization and energy efficiency.

Connectivity: A Key Enabler

Action is needed to reduce emissions from new networks, adopt energy-efficient cloud solutions, and integrate climate resilience.

This report focuses on all three scopes:



Telecom Sector Emissions



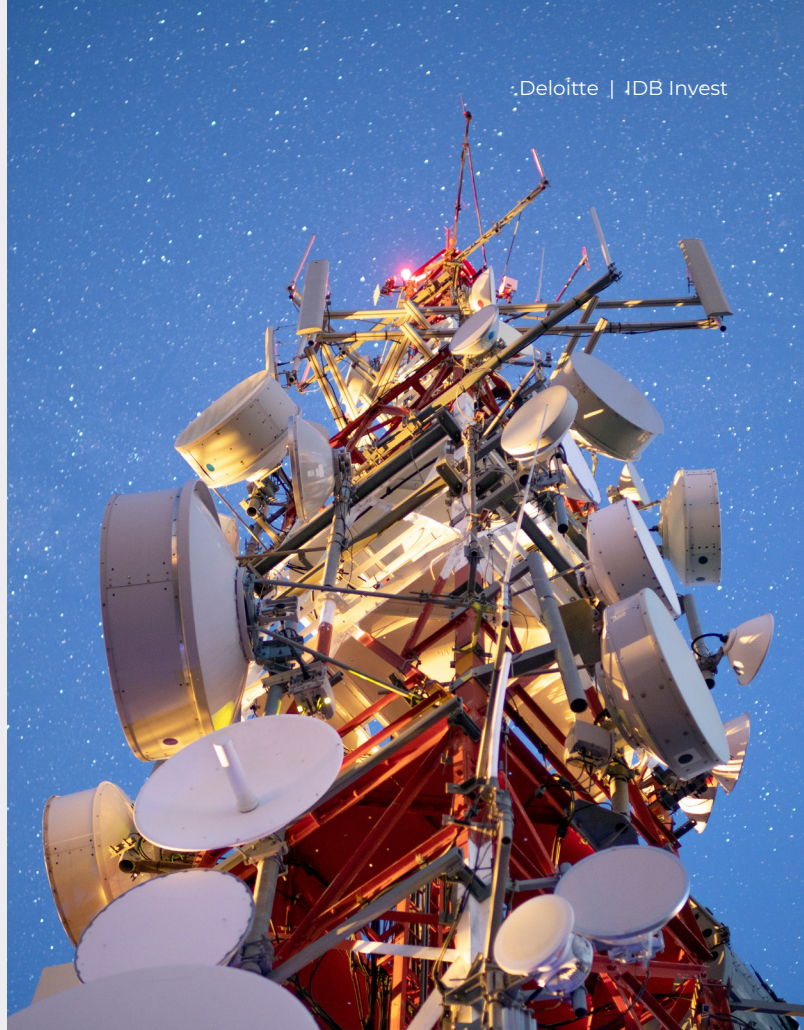
Initiatives to Mitigate Emissions



Climate Hazards Impacts and A&R Strategies



Enabled Climate Action Via Digitalization



Inaction leads to rising energy costs, stricter regulations, and increased investor scrutiny, **while prioritizing efficiency reduces expenses and boosts competitiveness and top line growth.**

Investing in sustainable networks and energy-efficient cloud solutions offers significant **economic advantages.**

Sustainability strategies can boost **EBITDA** by **5% to 15%** through **brand** perception, attracting **responsible investors** or generating **new revenue** from **sustainable products**. For Latin American operators, the key challenges include cutting energy consumption, transitioning to renewables, and reinforcing infrastructure to withstand extreme climate events.

State-of-the-Art of Mitigation Solutions for Fixed Broadband Deployment

Why Must Telecom Operators Invest in the Green Transition?

The telecommunications sector plays a fundamental role in the **transition to a low-carbon economy**, both due to its impact on energy consumption and its ability to drive sustainable digital solutions.

Adopting a more sustainable business model is not only an environmental responsibility but also a **competitive advantage, reducing costs and strengthening corporate reputation**.

To achieve this, it is essential to advance decarbonization by integrating clean energy, optimizing infrastructure, and **leveraging innovative technologies to minimize the carbon footprint**.



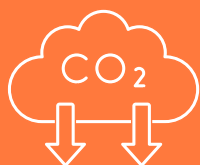
The transition to more sustainable models poses a series of risks and challenges,

including the obsolescence of infrastructure based on polluting technologies, regulatory changes requiring additional investments, and fluctuations in the carbon and renewable energy markets.

For telecommunications operators, the challenge lies in updating their networks and data centers without affecting service quality or disproportionately increasing costs.

In Latin America, where some economies face infrastructure and financing limitations, the transition **must be accompanied by government incentives and collaborations with the private sector.**

This chapter will analyze the operations of ICT companies, identify digital solutions for decarbonization, and conduct a benchmark of data centers considering PUE and WUE measures:



Breakdown
of Emissions in
Telco Operations



Identification
of
Solutions



Prioritization
of
Solutions



Regional
Benchmark of
Data Center

Telecommunications operators in Latin America have the opportunity to lead the green transition by implementing sustainable technologies, adopting renewable energy, and developing digital solutions for other sectors. **Decarbonization** not only contributes to the fight against climate change but also **generates economic benefits and enhances business competitiveness.** However, the **risks of transition** require proactive strategies to ensure a sustainable and **efficient evolution of the sector.**

Structuring of Operations

Telecom operator activities contribute to GHG in many ways, e.g., commercial operations not only include service centers or offices, but also logistics and transportation. Similarly, corporate operations include energy used for office facilities and emissions produced by employee commuting. This section provides a detailed breakdown of the sub-activities within each category that contribute to GHG emissions.

Telecom operator activities can be divided into 4 main categories

Service Provision

- **Network design and planning:** Strategic network design and layout, including the determination of locations for deployment of infrastructures.
- **Logistics:** Equipment procurement transportation, transportation of personnel and storage.
- **Infrastructure installation:** Tower Assembly, Transmission line installation, base station and Data Center and Backbone Installation.
- **Infrastructure decommissioning:** Decommissioning of infrastructure such as towers, fiber, copper, computers, servers from data centers and office equipment.
- **Equipment provision:** Provisioning and distributing devices like mobile phones, routers and modems to end users.

Network Management

- **Operations center:** Monitoring and management of networks, with high energy use from servers, cooling systems, and backup generators, driving GHG emissions.
- **Data centers:** Data centers consume energy for storage, cooling, and backups, with emissions from power use and IT hardware production.



Network Management

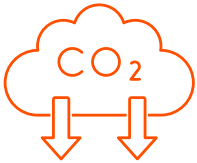
- **Operation:** Network components like antennas and base stations consume electricity, with backup generators adding to emissions during outages.
- **Maintenance:** Inspections, repairs, and upgrades require transport, machinery, and energy, with indirect emissions from equipment replacement and disposal.

Commercial Operations

- **Customer service centers:** Handle customer support and account management, with emissions from energy use for lighting, cooling, and IT systems.
- **Sales Offices:** Physical locations for customer engagement, with emissions from electricity use and employee travel, including commuting and business trips.
- **Customer acquisition:** Customer acquisition and support through travel, with GHG emissions from fuel consumption by vehicle replacement and disposal.

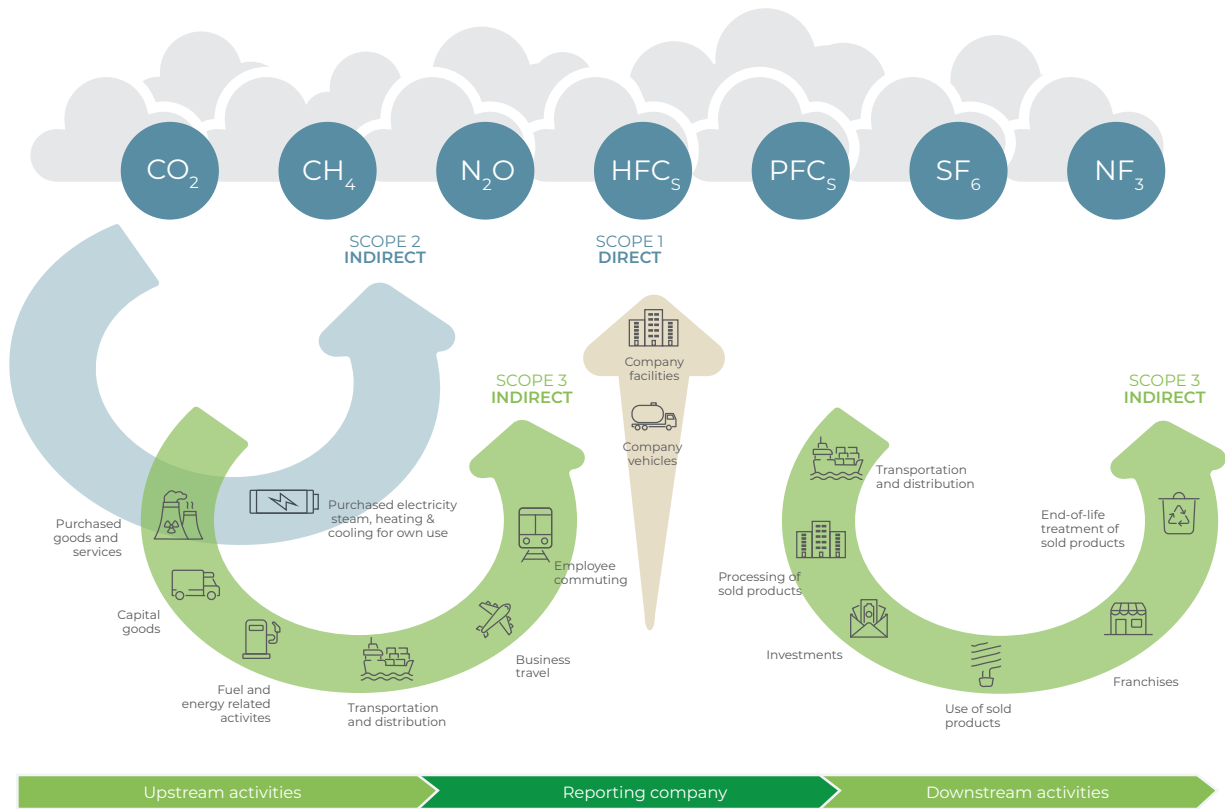
Corporate Operations

- **Management:** Strategic planning and oversight, with carbon emissions produced by office energy use, business travel, and communication technologies.
- **Administration:** Support daily operations, with emissions from office energy use, equipment, and consumables like paper.



Breakdown of Emissions

The various activities carried out by a telecommunications operator can be categorized across the three scopes of emissions in which GHG emissions are classified.



Scope 1

Direct emissions from company-controlled sources, often smaller but significant for energy-intensive telecom infrastructure, this percentage may rise, particularly if they depend on power generators.

10%

Scope 2

Indirect emissions produced by grid electricity use, a major contributor for telecom companies due to energy-intensive network operations.

10-30%

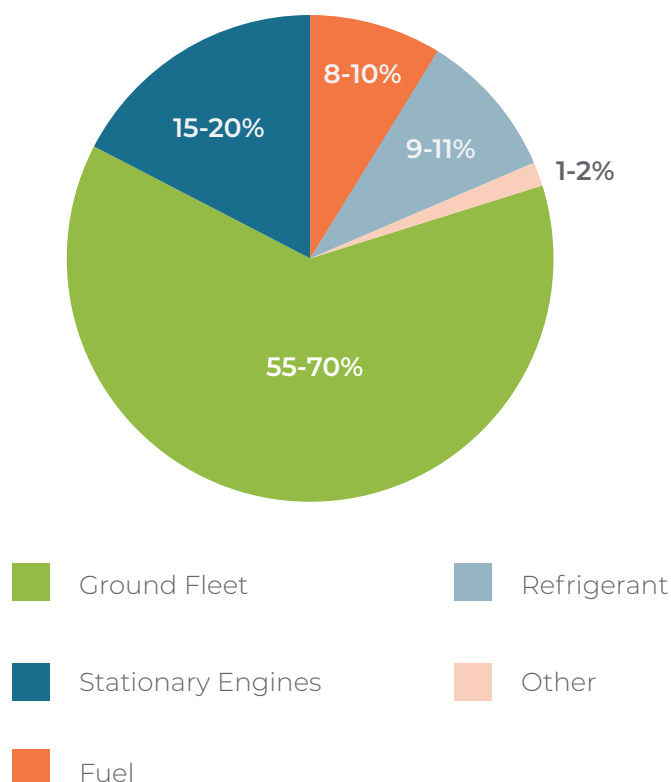
Scope 3

Indirect emissions that occur in the value chain, both upstream and downstream. It covers a broad range of activities, including the entire lifecycle of equipment, logistics and usage of devices.

60-90%

Percentage of emissions across each of the three scopes for a typical Mobile Network Operator (MNO)

Scope 1: Direct Emissions¹



Ground Fleet: Fuel used in transportation and maintenance vehicles, field visits, and transport between sales offices.

Stationary Engines: Backup generators at base stations, data centers, and offices.

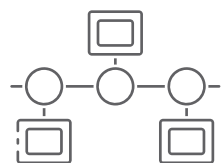
Operation Fuel Combustion: Testing generators, on-site fuel combustion, and facility maintenance equipment.

Refrigerant: Refrigerant leaks in HVAC systems.

Portable Engines: Mobile generator usage.

Flight Operations: Business travel with private aircrafts.

Scope 2: Indirect Emissions: Electricity Consumption²

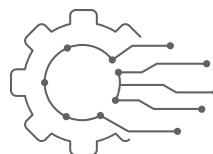


Network Access Sites:

Electricity for infrastructure installation, remote service facilities, base stations, and backup systems.



Offices: Electricity for lighting, HVAC, customer support systems, and office equipment.



Technology Centers:

Energy for data centers, transmission, network operations, HVAC systems, and backup systems.



Transport: Power consumption for electric vehicles, including transportation, maintenance, and drones.

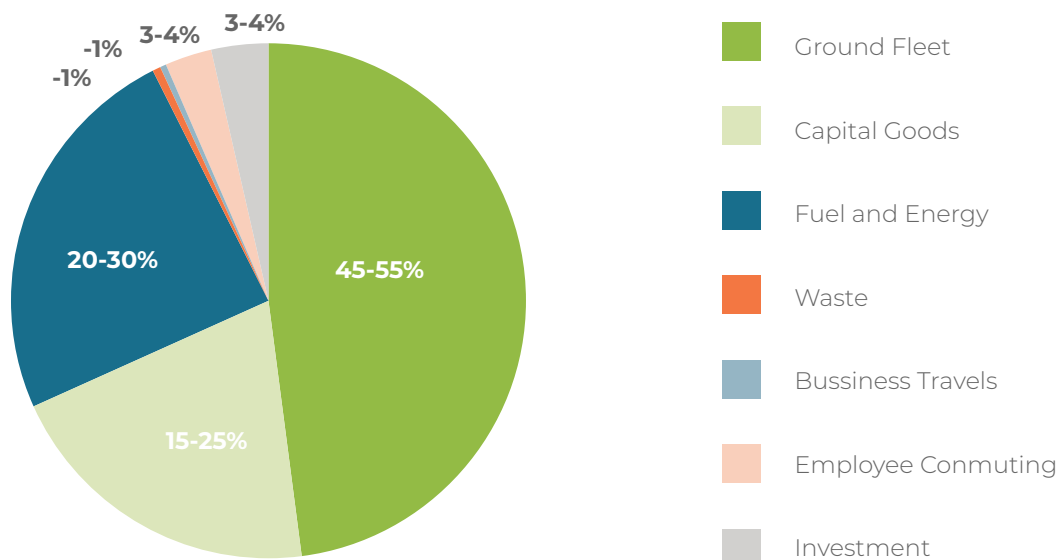
40% Network Access Sites

30% Technology Centers

2-4% Offices

1-3% Transport

Scope 3: Indirect Emissions: Up & Downstream³



UP
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M

- **Purchased Goods and Services:** Emissions from procuring materials, services, and supply chains.
- **Capital Goods:** Emissions from producing, transporting, and installing physical assets like servers and equipment.
- **Fuel- and Energy-Related Activities:** Emissions from the fuel supply chain.
- **Upstream Transportation and Distribution:** Emissions from transporting purchased products.
- **Waste Generated in Operations:** Emissions from waste disposal (e.g., cables, batteries, servers).
- **Business Travel:** Emissions from employee travel for work.
- **Employee Commuting:** Emissions from employees commuting to work.
- **Upstream Leased Assets:** Emissions from leased equipment and vehicles.

- **Investments:** Emissions from financial holdings, including shares, joint ventures, or other investments, tied to the activities of companies in which the telecom operator has invested.
- **Downstream Transportation and Distribution:** Delivering of products to customers, including related fuel supply chain emissions.
- **Use of Sold Products:** Energy consumption during the use of sold products.
- **End-of-Life Treatment of Sold Products:** Emissions from disposal, recycling, or treatment of products at the end of their lifecycle.
- **Downstream Leased Assets:** Operation of leased assets, such as telecom equipment or networks.
- **Franchises:** Franchise operations using the company's resources, including energy and fuel.

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Identification of Solutions

Telecommunications companies must reduce GHG emissions to address regulatory, technological, market, and reputational risks, particularly as global frameworks and local policies tighten. In Latin America, this is critical to align with initiatives like the SDGs, SBTi, and Net- Zero Standard. Beyond risk mitigation, these actions offer opportunities to strengthen market position, build trust, and drive innovation. By adopting best practices and aligning with global standards, operators can reduce emissions while fostering economic and social benefits.

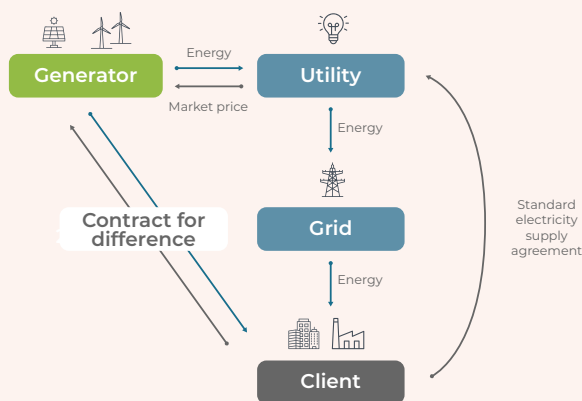


PV Panel Installation^{4,5}

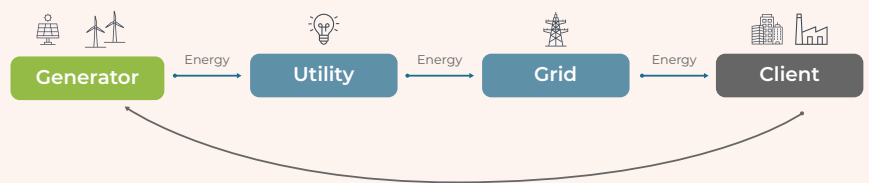
Installing solar panels at telecom sites and offices supplies renewable energy, reducing grid or generator reliance and cutting GHG emissions. Panels can be deployed at towers, network nodes, data centers, and cable landing points, often paired with batteries to store excess energy.

Companies like AT&T and Vodafone use solar power to replace diesel generators, cutting Scope 1 (fuel combustion) and Scope 2 (grid reliance) emissions. The initiative's impact depends on installation scale, location, and solar hours, though Scope 3 emissions from panel production and maintenance partially offset benefits.

Power Purchase Agreement^{5,6}



A **PPA** is a **long-term contract where a company buys renewable energy at fixed rates**, ensuring a stable supply while reducing emissions. Telecom firms like **AirTrunk** and **Amazon** actively use **PPAs**, with **Amazon** signing **44 PPAs totaling 6.2 GW** by 2021.



Synthetic PPA

Synthetic: The renewable energy generator sells electricity to the utility at market price under a standard agreement. The utility then channels this electricity through the grid to the client.

Sleeved: The generator sells electricity directly to the client. This structure reduces Scope 2 emissions by ensuring **grid electricity is 100% renewable**.

Sleeved PPA

Energy Efficiency

Infrastructure Sharing

Passive Equipment⁸: Operators **share passive elements**, like towers and electrical systems, but use separate antennas. Helios Towers in Africa achieved nearly **40% emissions savings by engaging in practices related to sharing infrastructure with other Mobile Network Operators**.

Duct⁹: Operators share trenches and ducts for fiber deployment, saving resources, costs, and **reducing emissions by up to 29%**. **Governments**, like Spain's CNMC, **mandate duct-sharing** to promote efficiency.

Active Equipment^{10,11,12,13}: Telecom operators share active and passive network components like antennas and masts, reducing infrastructure duplication, energy use, and emissions. **Shared RANs** can **lower energy consumption by over 40%**. This measure reduces emissions across all three scopes.

Intelligent Cooling of Data Centers¹⁴

This initiative uses AI to optimize data center cooling systems, employing machine learning to adjust temperature and airflow in real time. This improves energy efficiency, reducing power consumption and GHG emissions linked to traditional cooling methods like liquid cooling or ventilation. Google's DeepMind AI **reduced energy used for cooling by 40% in its data centers.**

Cold Aisle Containment and Dedicated Cooling in DCs^{15,16}

This initiative employs two compatible methods to reduce energy consumption in data center cooling processes:

- 1. Cold Aisle Containment:** Encloses cold aisles (where cool air is supplied to server inlets) to prevent mixing with hot exhaust air, improving cooling efficiency and reducing system workload. Studies by IBM show this approach enhances thermal efficiency and improves metrics like Supply Heat Index (SHI), Return Heat Index (RHI), and Coefficient of Performance (COP). Vertiv reports **combining cold aisle containment with intelligent control can cut energy consumption by 30%.**
- 2. Dedicated Cooling:** Focuses on directing cooled air to specific areas or equipment. **Manufacturers** claim these systems can also reduce **energy consumption by 30%.**



Circularity¹⁷

Eco-design in telecom infrastructure integrates environmental considerations into planning, deployment, and management to reduce emissions. It prioritizes energy efficiency, sustainable materials, and modular designs for easier upgrades. Partnering with green suppliers minimizes the carbon footprint across the infrastructure lifecycle, improves corporate sustainability, and ensures compliance with environmental regulations.

Climate Finance Tracking in the Telecommunications Sector

This table maps GHG mitigation activities in telecom to the Common Principles for Climate Mitigation Finance¹⁸, ensuring proper classification and eligibility under international standards while highlighting activities that reduce emissions.

	Greenfield/ Brownfield	Eligible Activity	Justification
Installation of PV Panels		2.1., 2.2., 9.1., 10.1., 10.2.	Eligible activities include on-site renewable energy sources and data centers
Renewable Energy PPA		2.1., 2.2., 9.1., 10.1., 10.2.	Emissions of the RE shall be lower than those from fossil fuel generation
Infrastructure Sharing		10.3.	Adoption of emerging technologies, resource-use efficiency and energy-efficiency plans
Intelligent Cooling in DCs		9.1., 10.1., 10.2.	Adoption of emerging technologies, resource-use efficiency and energy-efficiency plans
Cold aisle containment and dedicated cooling in DCs		9.1., 10.1., 10.2.	Energy-efficiency of the data center must comply with international best practices of PUE 1.4, depending on the region
Installation of LED lighting		9.1., 9.3., 10.1., 10.2.	Energy-efficiency of the data center must comply with international best practices
Replacement of legacy 4G networks by 5G		10.3.	The entity applying the modification shall demonstrate a reduction in emissions or better performance than standards or benchmarks
Replacement of copper network by optical fibers		10.3.	The entity applying the modification shall demonstrate a reduction in emissions or better performance than standards or benchmarks
Deployment of optical fiber using narrow trenching		10.3.	The entity applying the modification shall demonstrate a reduction in emissions or better performance than standards or benchmarks
Eco - design of Telecom Infrastructures, Products and Services		12.1.	The entity applying the modification shall demonstrate a substantial reduction in emissions considering material lifecycle sources such as where scope 3 emissions are expected to be material

Cost and GHG Reduction

In this section, a categorization of the initiatives is provided according to their impact and cost. The impact has been calculated based on the % of emissions reduction when the measure is implemented and the portion of total emissions tackled, while the cost is calculated based on financial investment, time of implementation and technical requirements.

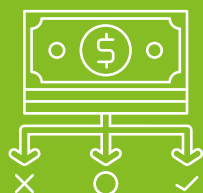
	% reduction	Portion Tackled	Cost
Installation of PV Panels	Dependent on size of installation	High	High
Renewable Energy PPA		High	Medium
Infrastructure Sharing: Active - Towers	> 40%	High	Medium
Infrastructure Sharing: Passive - Towers	< 40%	High	Low
Infrastructure Sharing: Duct	< 30%	High	Low
Intelligent Cooling in DCs	40%	Medium	Medium
Cold aisle containment and dedicated cooling in DCs	30%	Medium	Low
Installation of LED lighting	75%	Low	Low
Replacement of copper network by optical fibres	< 85%	Medium	High
Replacement of legacy 4G networks by 5G	90%	Medium	High
Narrow Trenching Techniques for Fiber Deployment	< 20%	Medium	Low
Co-Deployment of optical Fiber	< 15%	Medium	Low
Replacement of Diesel-Hydrogen Generators	100%	Low	Medium
Utilization of Electric Vehicles	50%	Low	Low
Network Equipment Circularity	Dependent on scope of the initiative and company's profile	High	High
Waste Reduction and Management		High	High
Eco - design of Telecom Infrastructures, Products and Services		High	High



Prioritization of Solutions

A sensible investment strategy in GHG mitigation solutions requires identifying sustainability initiatives that can provide the greatest benefits with the lowest implementation costs. Hence, it is essential to conduct a prioritisation that considers these two aspects. The methodology is shown below:

- The prioritization methodology is based on a two-axis classification system composed of both cost and impact.
- Each axis has a series of drivers that have been assessed to provide a grade ranging from 1 (low) to 5 (high), thus providing an estimation of the performance of each solution
- Finally, the initiatives have been plotted according to their grading, allowing to identify quick wins



COST

The first classification axis is characterized by cost, which includes economic cost, order of magnitude of the investment, time to implement and technical complexity.

Economic Investment (50%)

Economic cost of a solution is affected by both the cost of the equipment and technologies to be installed as well as by the capilarity of the solution.

Time of Implementation (30%)

Some initiatives can take longer to be implemented. For example, a renewable energy PPA could be a faster solution than installing solar panels in telecom towers.

Technical Requirements (20%)

Implementation of AI, sensorization, or leveraging hydrogen as a clean fuel can be particularly challenging, as these require a specialized workforce and there is limited availability of necessary equipment in LATAM



IMPACT

The second classification axis is defined by impact, which considers the individual impact of each initiative as well as the total volume of emissions that it can tackle.

Savings Potential (50%)

The savings potential of each initiative are compared, identifying the solutions that provide the highest % of carbon emissions savings

Emissions Base Affected (50%)

Each initiative applies a % reduction in carbon emissions to different GHG emissions bases. Hence, it is important to consider the scope of use of each initiative to estimate its impact.

Using the previously mentioned prioritisation criteria it is possible to categorize solutions and identify which of these should be applied first.



Quick Wins

Tower infrastructure sharing offers significant GHG savings at low cost and minimal barriers, making it a priority for Latin America.



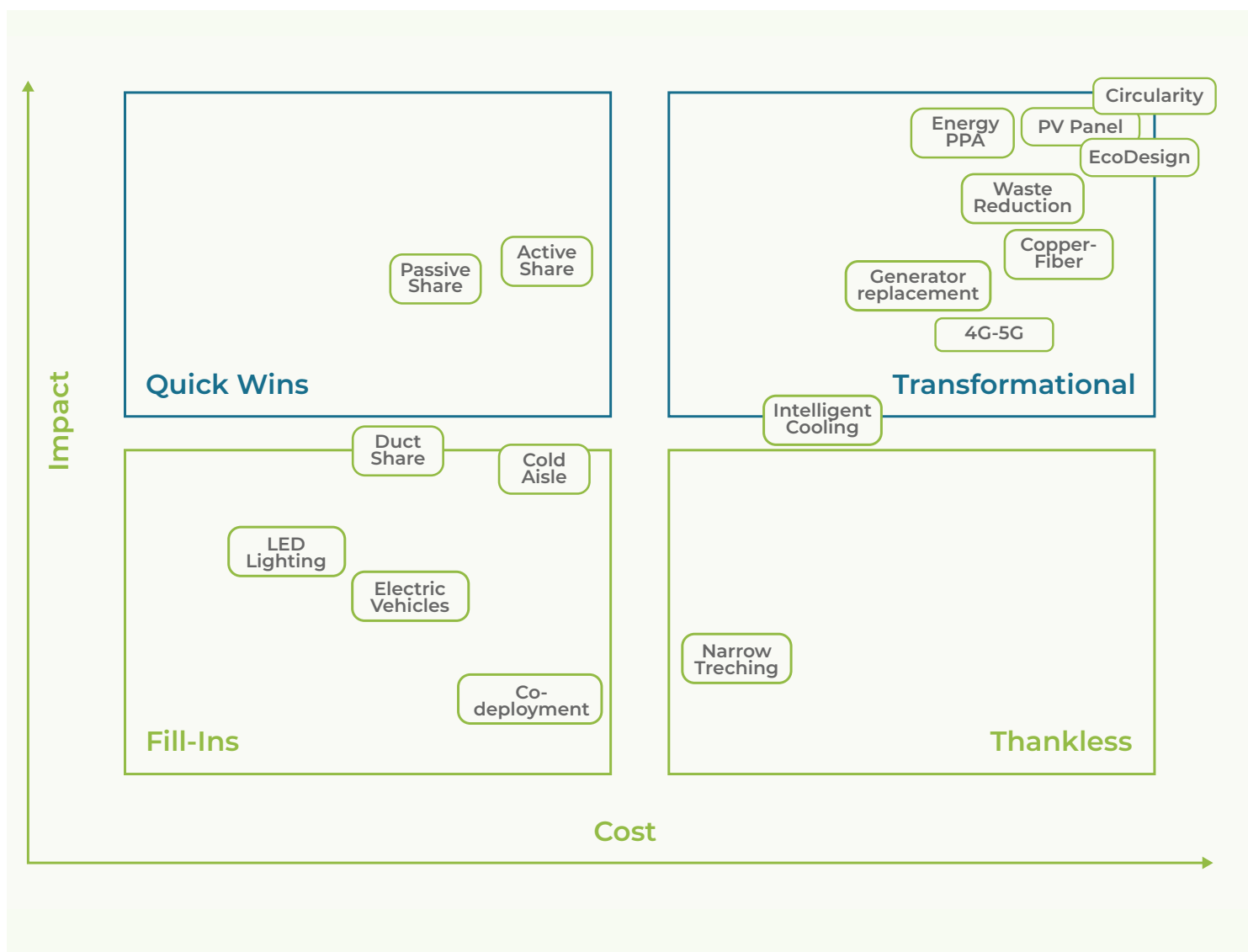
Transformational Initiatives

Renewable energy projects, fiber and 5G upgrades, and hydrogen generators provide substantial savings but involve high costs, technical complexity, and long implementation times.



Circularity

Most impactful for Scope 3 emissions but highly complex due to value chain control and limited regional maturity.



Priority actions for Latin America include low-cost measures like passive equipment and duct sharing, cold aisle containment, and LED lighting. Viable medium-complexity initiatives are intelligent cooling and renewable energy PPAs. High-impact, long-term actions include replacing copper with fiber optics and diesel generators with hydrogen.



Regional Benchmark of DC

Data centers are essential infrastructures in today's digital landscape, enabling the processing, storage, and management of **vast amounts of data**. They power everything from advanced **data analytics** and **artificial intelligence** to **cloud computing** and video streaming platforms, making them a **cornerstone** of the modern **digital economy**.



34 data centers in LAC with **installed capacities above 10MW** and completed from 2015 onwards were **benchmarked**.

Regarding ownership, over 20% of these data centers belong to Ascenty, followed closely by Elea Digital and ODATA, with 10, 9, and 8 data centers built since 2015 in Latin America and the Caribbean. Together, these three companies account for 60% of the region's data centers with these characteristics.

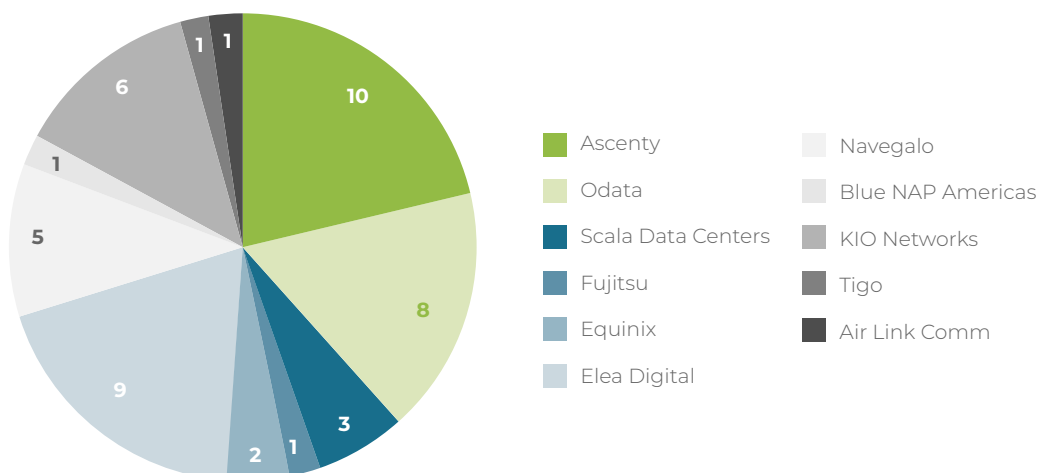
Key Players

Ascenty

ODATA

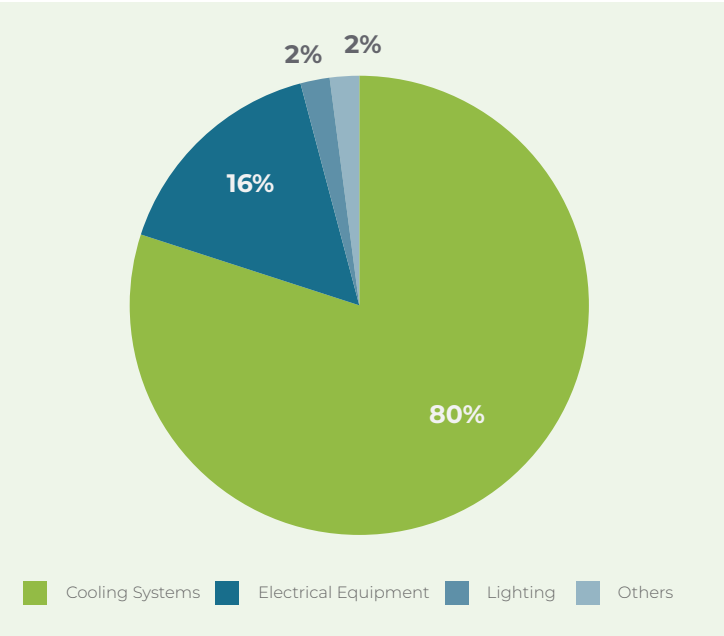
Elea
DATA CENTERS

KIO



PUE & WUE

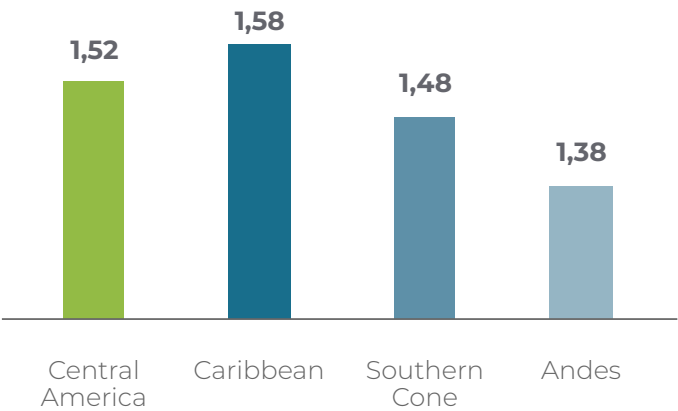
PUE and WUE are key metrics for **data center efficiency**. With the **exponential growth** of **data** and the increasing **demand** for **data centers**, energy efficiency has become a **critical factor**. This efficiency is measured through two key indicators: Power Usage Effectiveness (**PUE**), which assesses electricity consumption efficiency, and Water Usage Effectiveness (**WUE**), which evaluates water usage efficiency.



PUE measures the ratio between the total energy consumption of a data center and the energy used by its computing equipment. A lower PUE indicates higher energy efficiency and typically correlates with reduced GHG emissions. As seen in the graph, most of the non-IT energy consumption in data centers is attributed to cooling systems. This helps identify where emission reduction or efficiency measures can have the greatest impact. For example, **a measure that reduces lighting consumption by 50% will have a smaller effect than one that reduces cooling consumption by 10%.**

The **benchmark** shows an **average PUE of 1.48¹⁹** (range: 1.3–2), aligning with the **global average** by Uptime Institute but lagging **behind hyperscalers** like Google (1.1), Meta (1.08), and AWS (1.15). **Data centers in Latin America and the Caribbean should aim for PUE values below 1.3.**

PUE values are lower in Brazil and the Andes compared to the rest of Southern Cone Caribbean and CA. Brazil's leadership may stem from its larger market, enabling larger data centers with lower PUE, and a more developed data center ecosystem fostering energy-efficient technologies and skills. In contrast, **the Caribbean and CA show higher PUE**, indicating poorer efficiency.



Improving PUE²¹

Power Management Features

Utilize built-in server power management features to reduce IT and cooling power consumption during low utilization periods. CPU throttling, specifically through dynamic voltage and frequency scaling, can achieve up to **a 55% reduction in CPU energy consumption.**

Airflow Management

Manage airflow for cooling efficiency with tools like grommets, diffusers, and blanking panels to prevent cold air from mixing with hot exhaust air.

A large data center achieves **annual savings of \$360,000** through cost-effective airflow management measures.

Reduce Energy Losses from UPS Systems

Minimize energy losses in Uninterruptible Power Supply (UPS) systems by optimizing their efficiency, implementing high-efficiency models, and ensuring proper load management. **High efficiency PDUs are 2 to 3 percent more efficient** than conventional units.

Other initiatives

Efficient Data Storage Measures: can reduce the **amount of data stored by more than 95%.**

- Install in-rack or **in-row cooling: 3 times less energy in high-energy** density server rack than conventional cooling systems.
- Utilize **Containment/Enclosures:** containment systems can **reduce energy expense by 5-10%.**
- Change to a **Hot Aisle/Cold Aisle Layout:** in combination with containment, DOE estimates reduction in **fan energy use of 20 to 25%.**
- **Make humidification adjustments:** eBay's **ultrasonic humidification units save \$50,000** annually, a 2-year payback.

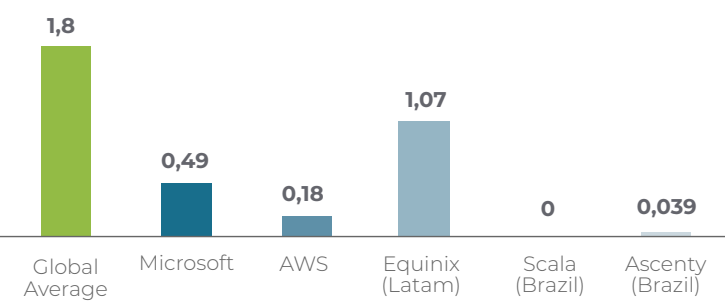
WUE

Water Usage Effectiveness measures water efficiency in data centers and supports sustainability goals. Location impacts WUE, with humid regions requiring less water for cooling, while arid or cold areas (e.g., Sweden, Finland) naturally reduce water use.

WUE =

Annual L of water for humidification and cooling

Total annual kWh used fot IT



In Brazil, **Scala Data Centers** is operating data centers with a **WUE of zero**, as their **HVAC systems employ air-cooled chillers**, without the need of Cooling Towers, which require continuous water replenishment.



Leverage Cooler Climates:

Data centers in cooler climates can utilize natural cold air for temperature regulation, reducing the strain on local water supplies.



Water Recycling²²:

Implement systems to recirculate water within cooling processes, like rainwater harvesting, gray water systems, or programs to return recycled water to local communities. This measure has a potential of saving between 50 – 70% of water, where these systems are implemented.

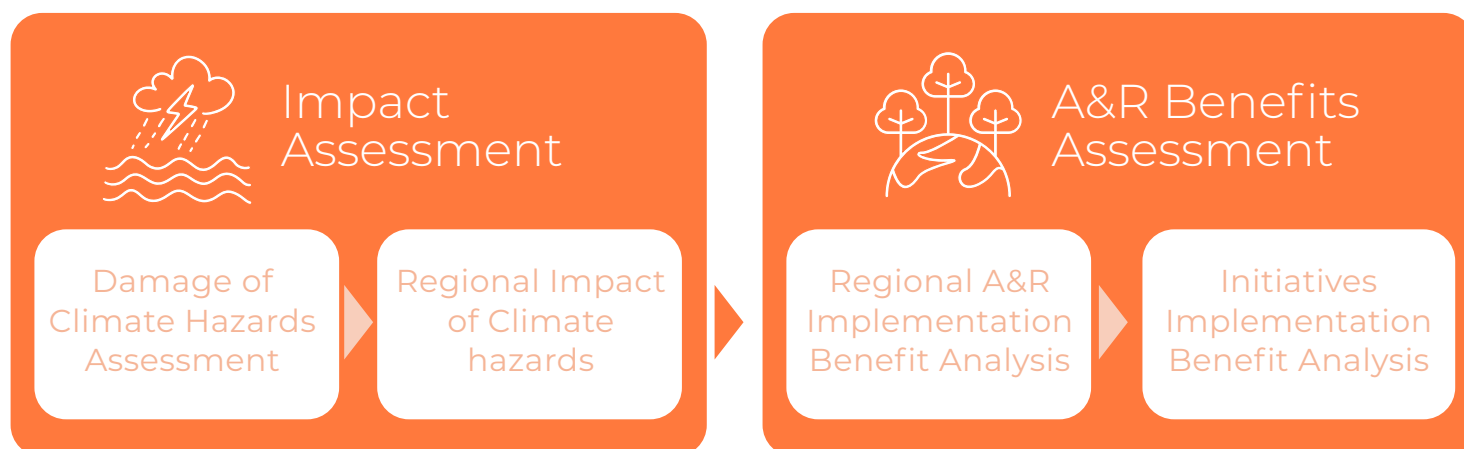
Impact Of Climate Hazards in LAC Region

Overview

The **assessment of the impacts of climate hazards** on infrastructure allows companies to establish resilience plans that address the costs related to all infrastructure and services belonging to the company. Anticipating the occurrence of natural disasters and establishing adaptability and resilience measures is essential to **ensure the proper functioning of all services provided by telecommunications companies**, particularly in environments affected by as many hazards as those in the LAC region.

Companies need to understand **which natural disasters are most relevant in their area** of operation and **the costs associated with these disasters** to take appropriate measures. For example, a company operating in the Caribbean must consider the high incidence of hurricanes and how they affect infrastructure, to design a resilience plan with initiatives primarily focused on mitigating the damage caused by this specific phenomenon.

The following step-by-step analysis has been carried out aiming to provide companies with a comprehensive perspective on where and how to design and implement resilience plans:



After processing all the information obtained through this analysis, a telecommunications company can, by knowing the value of its infrastructure, use the Impact Assessment to **identify which natural disasters most affect its area of economic operation** and the economic damages caused by each of these hazards in each of its operating areas.

Once the areas that incur the highest costs are identified, the A&R Benefit Assessment can be used to **pinpoint the most effective initiatives for each area and hazard**. These initiatives can then be tailored to the company's specific case, allowing the company to **develop an A&R plan with clear resilience objectives and estimated benefit outcomes**.



Impact in Digital Infrastructure

The LAC region suffers year after year from the effects of various hazards that impact the population and infrastructure, being the second most disasterprone region in the world with **190 million affected by 1534 disasters²³** from 2000 to 2022. These damages result in the need to invest in the recovery of the affected territories, their people, and their resources. The most notable hazards in terms of damage and frequency in this region are **seven**.

*United Nations Office for Disaster Risk Reduction (UNDRR)

Natural Hazards Assessment

Floodings

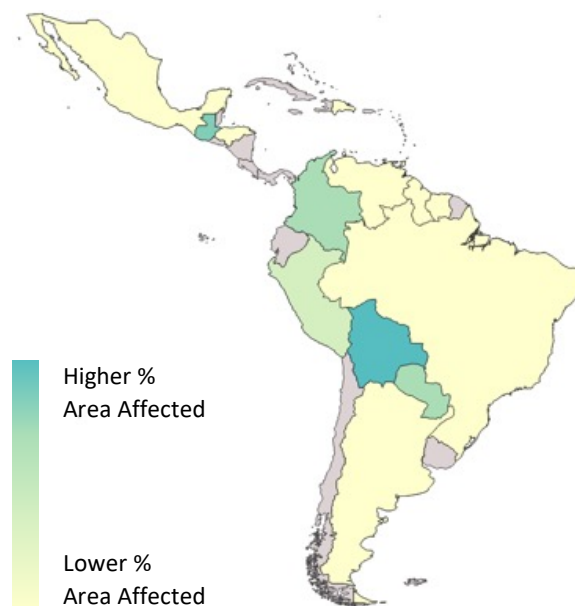
Flooding has become an increasingly significant issue in the LAC region. The destructive capacity of this hazard affects the entire network infrastructure, causing significant damage to the telecommunications companies' results.

56k km²

of area affected yearly²⁴

1.8M

of people affected yearly²⁴



Hurricanes

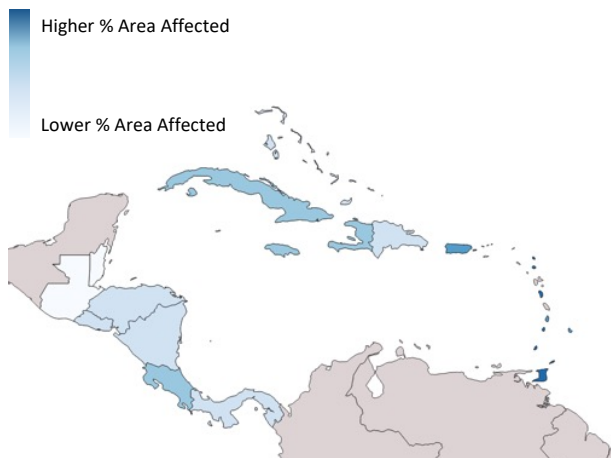
Hurricanes and tropical storms are among the most significant and destructive natural hazards in the LAC region. Its impact primarily affects surface installations, such as pole-mounted lines and base stations, forcing investment in the repair of this infrastructure.

30k km²

of area affected yearly²⁵

5M

of people affected yearly²⁵





Earthquakes

Earthquakes, although less common, have a greater destructive capacity and scope, causing significant damage to underground infrastructure and housing. Although not directly related to climate change, their significant impact in companies' economy and natural origin make them worthy candidates for analysis.

24k km²

of area affected yearly²⁶

1M

of people affected yearly²⁶

Wildfires

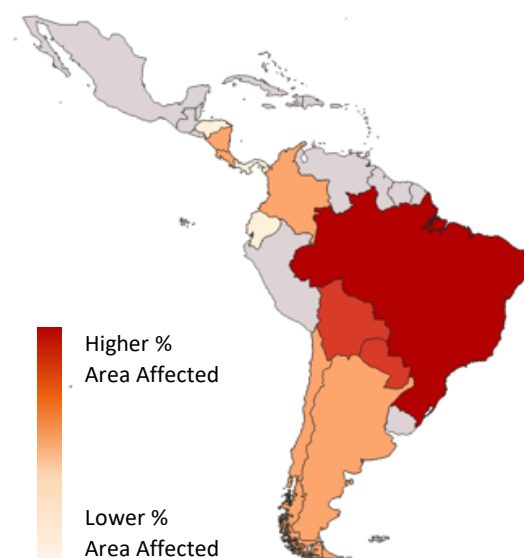
In recent years, the region has experienced a concerning increase in the number of wildfires, driven by both human activities and the effects of climate change. These wildfires pose significant risks to telecommunications infrastructure and companies' economy, damaging communication lines, cell towers and causing power outages.

42k km²

of area affected yearly²⁷

1M

of people affected yearly²⁷



Cold waves

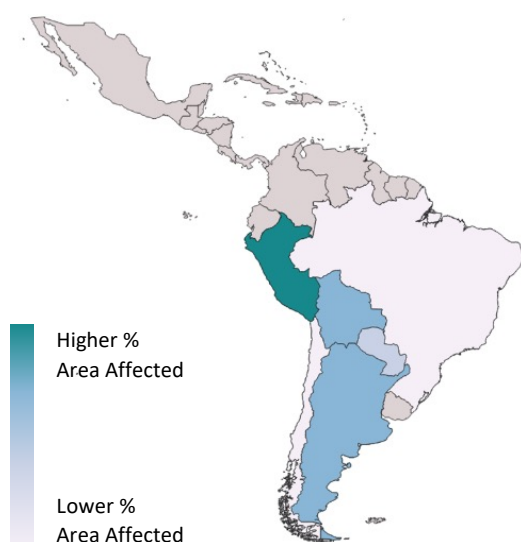
This cyclic phenomenon is also a concern in the southern region, particularly in high-altitude areas and southern regions like the Andes and Patagonia, damaging cooling systems, freezing telecom fiber optic cables and posing equipment and supply malfunctions, resulting in repair and indirect costs due to service interruptions.

95k km²

of area affected yearly²⁸

1.7M

of people affected yearly²⁸



Droughts

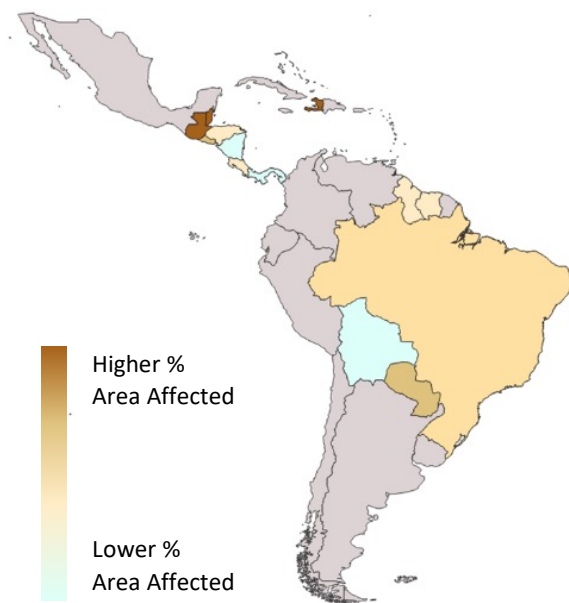
Just like cold waves, droughts raise concern due to their vast reach, duration and effect on indirect costs, creating vulnerabilities in supply and cooling systems due to lack of water and data centers, as well as causing soil shrinkages that can damage ducts and buried equipment as copper lines and fiber optic cables.

80k km²

of area affected yearly²⁹

2.4M

of people affected yearly²⁹



Heatwaves

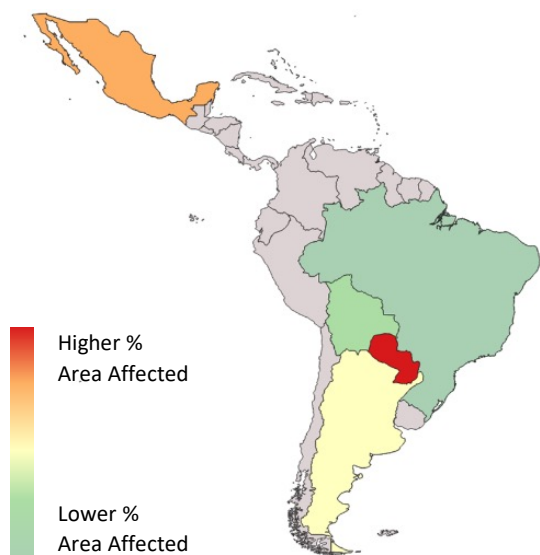
Extreme heat is becoming a significant concern for ICT infrastructure in the LAC region. Cooling systems, power supplies, and hardware struggle to maintain optimal functionality posing risks to the reliability, and longevity, reducing the amortization period and increasing investment in equipment renewal.

77k km²

of area affected yearly³⁰

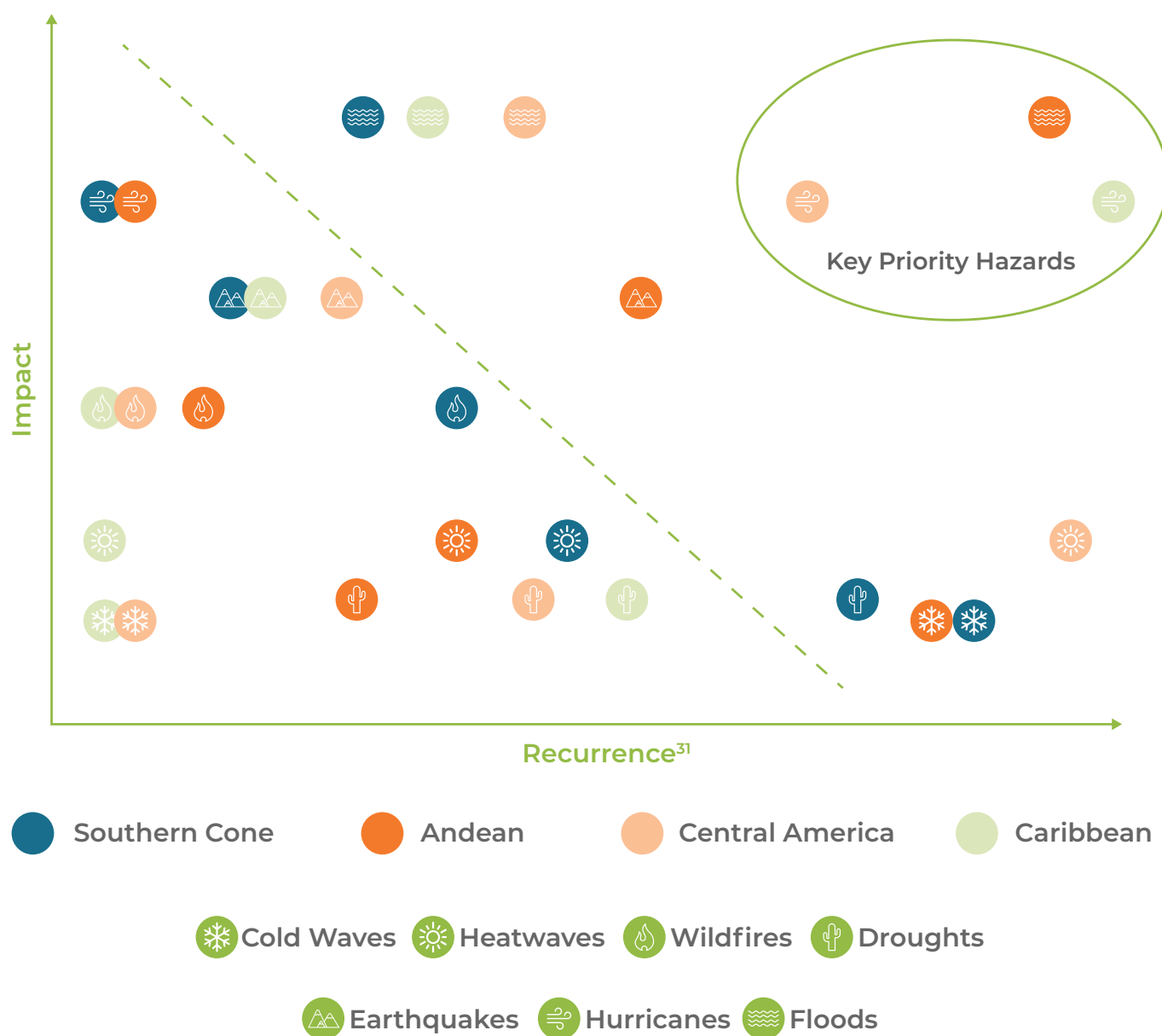
2.3M

of people affected yearly³⁰



Natural Hazards Regional Impact

To develop the hazard-impact matrix, an extensive methodology was applied, combining data on **costs, affected infrastructure, and population** for each hazard. The study first identified the effects on key telecom components, classifying them by direct and indirect costs. Each hazard was crossreferenced with its effects to determine **severity**. Recurrence data from the past 22 years highlighted frequent events like floods and hurricanes as priorities. By integrating severity and recurrence, a matrix was created to **prioritize hazards by impact** and the need to take action, enabling **tailored resilience measures** by subregion.



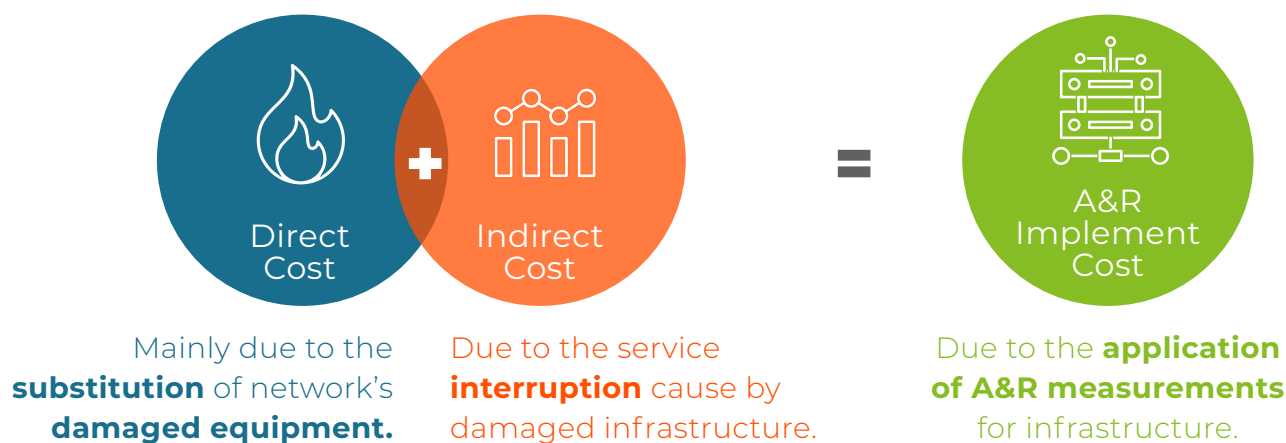
Note: Hazards ordered by number of occurrences in LAC region.

To identify the impact, the **severity** of the hazard has been studied, understood as the damage each hazard causes on different parts of the telecommunications network. This severity has been combined with the estimated **cost of damaging each of those parts**. As a result, a hazard that affects fewer parts of the network but does so more severely—and impacts parts with higher associated costs—may have a greater overall impact. To assess **recurrence**, the incidence of the different hazards over the years has been analyzed across the various sub-regions of the study area.



A&R Implementation

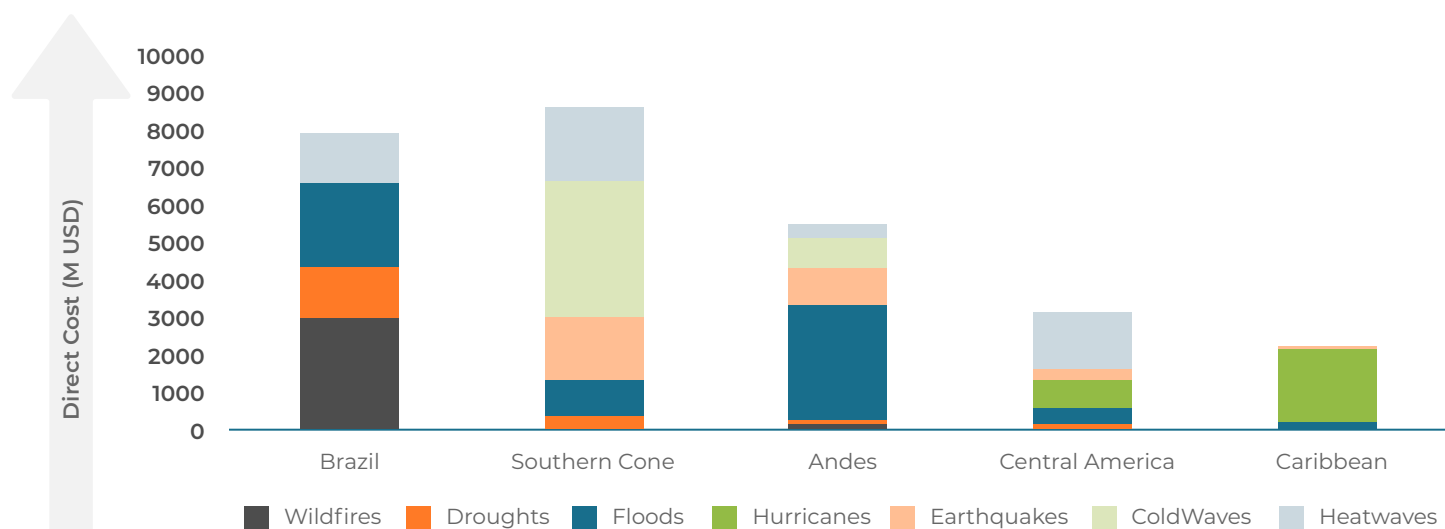
Costs generated by natural disasters can be mitigated by implementing adaptability and resilience (A&R) plans that target telecommunications infrastructure. To estimate the avoided costs or benefits, it is necessary to determine the cost incurred from the destruction of the infrastructure and the expenditure required to implement the resilience plan.



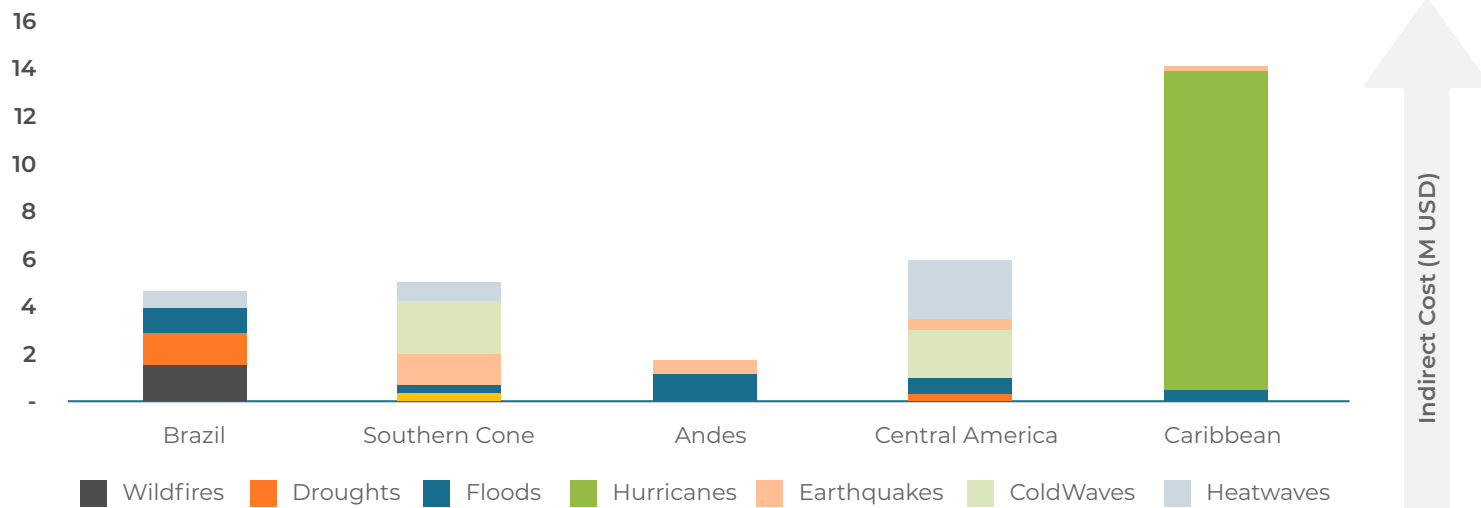
To calculate **direct costs**³², the extent of the effects of natural disasters in each country has been assessed and cross-referenced with the **estimated value of the telecommunications network** in each country. For **indirect costs**³³, a study was conducted based on **service interruptions** and their associated costs for significant natural disasters.



Each hazard affects the infrastructure of each region differently. For example, **cold waves** do not impact the Southern Cone and Central America in the same way. Brazil has been analyzed separately from the other regions due to its **significant cost impact**, as its total cost is higher than that of, for example, the entire Andean region.



When analyzing indirect costs, which are strongly related to population density, the Caribbean region stands out. In particular, **hurricanes** cause the greatest service disruptions, leading to the **highest indirect costs** directly associated with these outages.



Regional A&R Implementation Benefit Analysis

16.6B USD

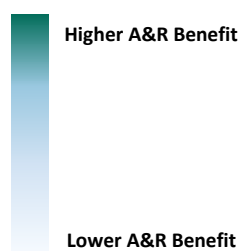
The **Southern Cone** stands out as the region with the greatest benefit, led by Brazil with 7.9 Billion, primarily due to having the largest area with affected infrastructure.

2.5B USD

Due to factors as area and infrastructure, in the **Central American** countries, Mexico stands out, accounting for more than 80% of the total benefit in the region.

5.5B USD

Addressing the damages caused by the most destructive hazard, floods, the **Andean region** is the second most benefited, with Bolivia leading as the country with 3 Billion.



2.2B USD

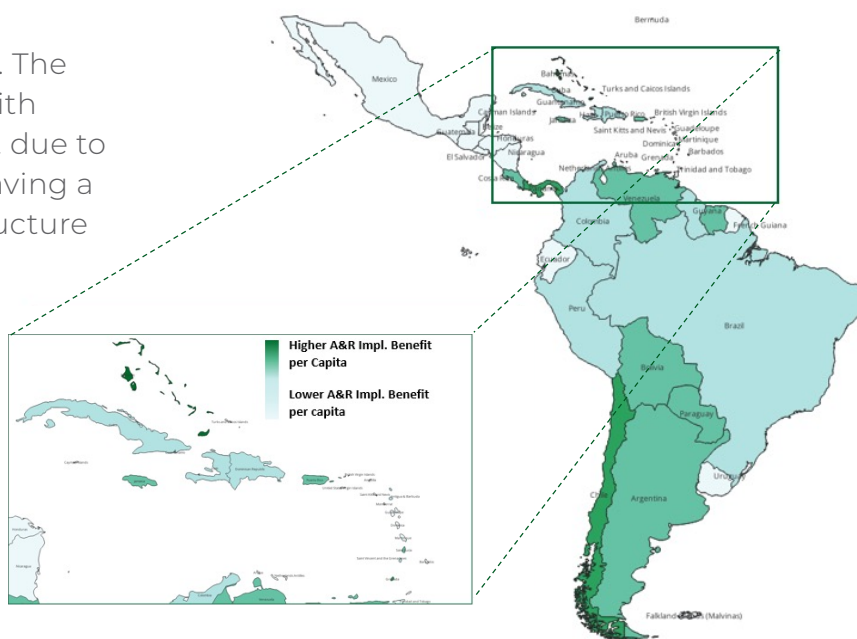
The distribution of benefits in **the Caribbean** is more uniform, spread across more than 10 countries in the study, primarily aiming to mitigate the damages caused by hurricanes.

Identifying the regions and countries with the greatest **benefit³⁴** allows for the prioritization of specific **A&R (Adaptability & Resilience)** initiatives for implementation.

As an intermediate step between the regional study and specific initiatives, an analysis is conducted to gain new insights that may aid in the prioritization of initiatives. The general study is strongly related to the connected area of each country. Given the significant differences between countries, it may be useful to evaluate **the benefit per capita or per square kilometer**.

Observing the **per capita study**³⁵, very different countries and regions stand out. The **Caribbean** now emerges as a key area, with countries like **the Bahamas** standing out due to being hit by more destructive hazards, having a smaller population with a higher infrastructure penetration.

Bahamas	1,170 USD	per capita
Bolivia	243 USD	per capita
Paraguay	157 USD	per capita
Chile	154 USD	per capita
Argentina	96 USD	per capita



The **study by km²**³⁶ further accentuates the predominance of Caribbean countries on an individual level, now led by **Barbados and the Bahamas**. With smaller land areas but a high impact of hazards, the density of impact per square kilometer increases significantly.



Barbados	37k USD	per Km ²
Bahamas	34k USD	per Km ²
Puerto Rico	21k USD	per Km ²
Costa Rica	8.8k USD	per Km ²
Chile	7.5k USD	per Km ²

The **per capita study** prioritizes **infrastructure protection** in terms of service quality for residents, while the **per km² study** focuses on ensuring that the areas where initiatives are implemented can **continue providing service**, regardless of population presence, particularly relevant for habitation, tourism, and other activities.

Prioritization Ranking

These two analyses can be **combined using normalization** to define a final ranking of prioritization by country. By giving equal weight to both the affected population and the affected area, a balanced relationship can be established, allowing for a **new prioritization of countries**.

Cross-Normalized Indicator Formula

$$PNorm_j = \frac{P - P_{min}}{P_{max} - P_{min}}$$

$$ANorm_j = \frac{A - A_{min}}{A_{max} - A_{min}}$$



Once again, **Caribbean** countries **stand out**, but their **priority ranking changes**, allowing countries from other regions to gain more prominence in the prioritization process.

This study **disadvantages large countries** with lower population density, such as **Brazil or Argentina**, even though they are also affected by disasters and incur significant costs and damages. It is **essential to not lose sight of the regional analysis**, which shows that the most affected region overall is the **Southern Cone**, where both countries are located.

Climate Resiliency Initiatives

To enhance adaptation and resilience to the various climate hazards outlined, it is essential to adopt a **comprehensive approach** that combines technological advancements, infrastructure improvements, and operational adjustments. This sections introduces the application of separate initiatives to address these challenges effectively.

First, **general initiatives** applicable **across all hazards** are presented before delving into those specific to each hazard. As shown, each initiative impacts different components of the telecommunications infrastructure, highlighting their varied effects. Finally, **hazard-specific initiatives** are detailed, including the **costs savings** achieved in **each subregion**, offering a clear **prioritization framework** for **implementation**.

A&R Initiative	Description	Telecom Infrastructure Affected
Redundant Network Paths³⁷	Create multiple, redundant network paths that use different physical routes (underground, overhead, satellite) to ensure that if one part of the network is disrupted, services can continue through alternate pathways.	<ul style="list-style-type: none"> • Fiber Networks • Base Stations
Monitoring and Early Warning System³⁸	Implement continuous monitoring systems using IoT sensors and AI to provide early warning for climaterelated events and take preventive action to protect infrastructure .	<ul style="list-style-type: none"> • DCs • Fibre Networks • Base Stations
Collaboration with Government and Agencies³⁹	Partner with governments and emergency services through MOUs and joint training programs to prioritize telecom restoration and improve disaster response times.	<ul style="list-style-type: none"> • DCs • Fibre Networks • Base Stations
Sustainability and Energy Efficiency Initiatives⁴⁰	Align climate strategies with sustainability by adopting renewable energy, energy-efficient technologies, and green-certified infrastructure to enhance resilience and minimize environmental impact .	<ul style="list-style-type: none"> • DCs • Fibre Networks • Base Stations
Disaster Recovery Planning⁴¹	Develop comprehensive recovery plans with offsite data backups and satellite-based systems to ensure swift restoration of services post-disaster.	<ul style="list-style-type: none"> • DCs • Fibre Networks • Base Stations
Automated Failover Systems⁴²	Equip data centers with automated failover systems that switch to alternative power sources and networks in case of disruptions.	<ul style="list-style-type: none"> • DCs

A&R Initiatives per Hazard

The following tables outline potential measures tailored to address each specific climate hazard, offering a detailed analysis of their benefits and effectiveness. The avoided costs for each initiative, calculated across the various infrastructure components they impact, have been consolidated to present a clear and complete picture of their overall benefit. The calculation of implementation costs for each initiative depends on the specific conditions of each country and region. Therefore, **this section focuses on presenting the benefits of the application of the proposed measures, expressed as avoided costs**, to highlight their effectiveness in enhancing resilience and reducing vulnerabilities.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Flood-Proof Infrastructure ⁴³	M \$2,038	M \$1,992	M \$300	M \$85
Rainwater Drainage Systems ⁴⁴	M \$163	M \$159	M \$24	M \$6
Landslide Monitoring Systems ⁴⁵	M \$1,745	M \$1,706	M \$257	M \$73
Modular Data Centers ⁴⁶	M \$173	M \$169	M \$25	M \$7

Floodings



Highest cost savings per capita.

The vulnerability of **data centers to flooding** underscores the need for robust mitigation strategies.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Storm-Resistant Infrastructure ⁴⁷	M \$0	M \$0	M \$180	M \$463
Waterproofing of Critical Infrastructure ⁴⁸	M \$0	M \$0	M \$315	M \$807
Decentralized Cloud Infrastructure ⁴⁹	M \$0	M \$0	M \$39	M \$100
Saltwater-Resistant Materials ⁵⁰	M \$0	M \$0	M \$437	M \$1,113
Emergency Communication Systems ⁵¹	M \$0	M \$0	M \$1	M \$4

Hurricanes



Highest cost savings per capita.

Data Centers and base stations are the components that extract the higher benefit from these initiatives.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Harden Communication Lines⁵²	M \$1,605	M \$58	M \$1	M \$0
Defensible Space Around Cell Towers⁵³	M \$828	M \$30	M \$1	M \$0
Use Fire-Resistant Equipment⁵⁴	M \$824	M \$30	M \$1	M \$0
Robust Power Backup Solutions⁵⁵	M \$173	M \$2	M \$0	M \$0
Smoke Filtration Systems⁵⁶	M \$49	M \$2	M \$0	M \$0

Wildfires



Highest cost savings per capita.

Wildfires initiatives are the most useful when data center and fiber network endurance is compromised.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Seismic-Resistant Construction⁵⁷	M \$282	M \$161	M \$41	M \$3
Flexible Cable Design⁵⁸	M \$1,100	M \$628	M \$160	M \$13
Disaster Recovery Planning⁵⁹	M \$1,135	M \$648	M \$164	M \$13
Automated Failover Systems⁶⁰	M \$52	M \$30	M \$8	M \$1

Earthquakes



Highest cost savings per capita.

Earthquakes pose significant threats to the operation and reliability of **data centers and fiber networks**.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Energy-Efficient Infrastructure⁶¹	M \$112	M \$12	M \$56	M \$0
Efficient Cooling Technologies⁶²	M \$142	M \$14	M \$66	M \$0
Heat-Resistant Components⁶³	M \$1,910	M \$185	M \$882	M \$0
Solar-Powered Data Centers⁶⁴	M \$447	M \$43	M \$207	M \$0
Localized Microgrids⁶⁵	M \$545	M \$53	M \$252	M \$0

Heatwaves



Highest cost savings per capita.

Effective measures are critical to safeguard **data centers and base stations** from the adverse effects of **heatwaves**.



A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Waterless Cooling Systems ⁶⁶	M \$308	M \$18	M \$11	M \$7
Rainwater Harvesting Systems ⁶⁷	M \$330	M \$19	M \$12	M \$7
Infrastructure Monitoring for Soil Movement ⁶⁸	M \$408	M \$24	M \$15	M \$9
Diversified Energy Supply ⁶⁹	M \$977	M \$57	M \$36	M \$22

Droughts






Highest cost savings per capita.

Data centers and fiber networks are the units that suffer the most tough effects of droughts.

A&R Initiative	Southern Cone	Andean	Central America	Caribbean
Cold-Resistant Materials ⁷⁰	M \$2,174	M \$492	M \$0	M \$0
Heating Systems for Critical Components ⁷¹	M \$765	M \$173	M \$0	M \$0
Insulation of Data Centers ⁷²	M \$99	M \$22	M \$0	M \$0
Redundant Connectivity for Cold Regions ⁷³	M \$2,229	M \$505	M \$0	M \$0

Cold Waves



Highest cost savings per capita.

Specific cold wave initiatives should be implemented in key regions to maintain the proper function of base stations.

Use Case Exemplification of A&R Plan Development

The information gathered in this report, as outlined in the introduction, is intended to help telecommunications companies identify the vulnerabilities in their network that need to be addressed in response to the impact of natural disasters in their area of economic activity. This subsection presents an **illustrative case** demonstrating how all the collected information can be used **to implement a resilience and adaptability plan in the most effective way**, maximizing the efficiency of the initiatives implemented and minimizing the damages avoided.



The second largest telecommunications company in the Central American market aims to develop an **adaptability and resilience plan** for its telecommunications infrastructure. This company holds **35% of the infrastructure** (and so, market share) in the region, with economic activities particularly concentrated in **Honduras, El Salvador, Guatemala, and Nicaragua**.



>35%

of the infrastructure



Once the countries where economic activity takes place have been identified, it is possible to **analyze the hazards affecting each of them** and determine which ones have the greatest impact according to the **Impact-Resilience Matrix**. This analysis shows that, among the hazards affecting the countries under study, **hurricanes and floods generate the highest impact** and, therefore, the highest costs.

If the selection is prioritized based on the hazards with the greatest impact, the focus will be placed on **initiatives targeting these specific hazards**. If a more specific approach where to be defined, broader initiatives would be selected (highlighting that these more general initiatives with higher benefits will also tend to require a greater financial investment for their implementation).



A&R Initiative	Central America	Company Share (35%)
Flood-Proof Infrastructure ⁴³	M \$300	M \$105
Storm-Resistant Infrastructure ⁴⁷	M \$180	M \$63
Rainwater Harvesting Systems ⁶⁷	M \$12	M \$4.2

In the case of wanting to **focus the exercise on a specific part of the network**, such as the fixed or mobile network, the **priority should simply shift to initiatives that strengthen that specific infrastructure**. This should always be done while keeping in mind which hazards have the greatest impact in the area under study.

Initiatives Linkage to Adaptation Finance Guidance



The classification below maps A&R activities according to the **Joint Methodology for Tracking Climate Change Adaptation Finance⁷⁴**, ensuring alignment with the Common Principles. This distinction provides a clear framework for assessing the eligibility and objectives of each initiative, offering a structured approach to address climate adaptation.

Legend:

General



Earthquakes



Floods



Hurricanes



Heatwaves



Wildfires



Droughts



Cold Waves


Type 1: Adapted activities - Activities that integrate measures to manage physical climate risks and ensure that the project's intended objectives are realized despite these risks. These activities include adjustments or improvements required to ensure that the project performs well against experienced and anticipated impacts of climate change. Adaptation is not the primary objective of the activity.


Sustainability and Energy Efficiency Initiatives	Heat-Resistant Components	Defensible Space Around Cell Towers	Flood-Proof Infrastructure
Efficient Cooling Technologies	Harden Communication Lines	Modular Data Centers	Weatherproof Data Centers
Use Fire-Resistant Equipment	Rainwater Drainage Systems	Cold-Resistant Materials	Smoke Filtration Systems
Flexible Cable Design	Heating Systems for Critical Components	Saltwater-Resistant Materials	Energy-Efficient Infrastructure
Storm-Resistant Infrastructure	Waterproofing and Elevation of Critical Infrastructure		


Type 2: Activities that directly reduce physical climate risk and build the adaptive capacity of the system within which the activity takes place. These activities are typically identified based on a robust understanding of physical climate risks faced by the system within which the project takes place.


Redundant Network Paths	Decentralized Cloud Infrastructure	Diversified Energy Supply
Robust Power Backup Solutions	Localized Microgrids	Redundant Connectivity for Cold Regions
Solar-Powered Data Centers	Seismic-Resistant Construction	


Legend:


 General


 Earthquakes


 Floods

 Hurricanes

 Heatwaves

 Wildfires

 Droughts

 Cold Waves

Type 3: Enabling adaptation – Activities that contribute to reducing the underlying causes of vulnerability to climate change at the systemic level and/or removing knowledge, capacity, technological and other barriers to adaptation. This type of activity supports adaptation beyond its immediate scope by creating enabling conditions for policy and regulatory environment developments, physical or natural asset enhancements, capacity strengthening, technology developments or knowledge enhancements. These activities are themselves adjusted to cope with the experienced and anticipated impacts of climate change. Adaptation is the primary objective of the activity.

Monitoring and Early Warning Systems	Collaboration with Government and Agencies	Landslide Monitoring Systems
Emergency Communication Systems	Disaster Recovery Planning	Automated Failover Systems
Waterless Cooling Systems	Infrastructure Monitoring for Soil Movement	Rainwater Harvesting Systems

The classification outlined in these slides gathers an approach to linking initiatives to adaptation finance, in alignment with the **Joint Methodology for Tracking Climate Change Adaptation Finance**. By categorizing activities into three distinct types, adapted activities, direct risk mitigation, and enabling adaptation, the framework ensures a structured pathway to address climate adaptation.

This systematic distinction supports stakeholders in identifying, designing, and financing adaptation initiatives with clarity and precision. By addressing a spectrum of challenges, ranging from immediate physical risks to systemic vulnerabilities, this guidance fosters robust, sustainable responses to climate change impacts across various sectors and geographies.

Climate Enablement Effect for Fixed Connectivity

Climate Enablement

Telecommunications infrastructure and solutions are key enablers of digital transformation. By supporting technologies such as IoT, AI, and Big Data, they enhance efficiency across social and productive sectors, reducing GHG emissions and optimizing resource use.

This digital evolution not only strengthens competitiveness but also paves the way for a more **connected and sustainable future**.

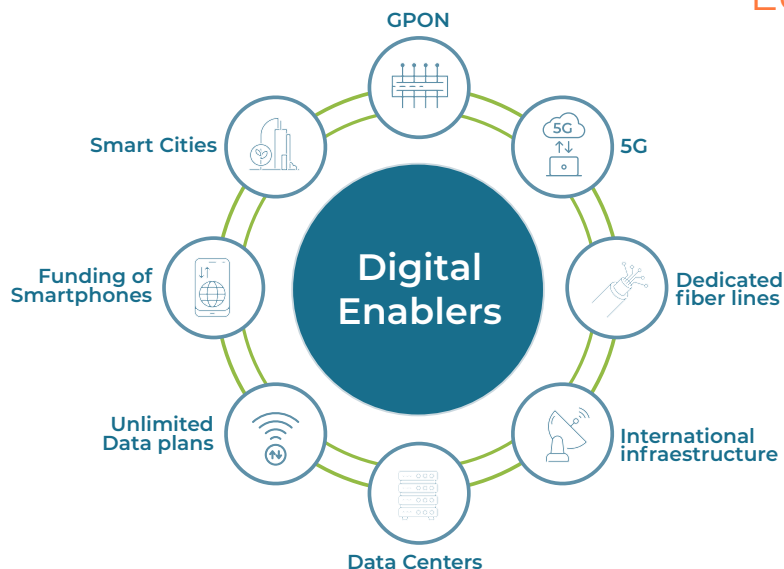
Digitalization Enablers

Social Impact

Digitalization

enhances access to essential services, boosting **inclusion and efficiency**. Fiber optics and mobile networks enable **online learning**, reducing educational gaps. **Telemedicine** and AI diagnostics improve healthcare access and hospital efficiency.

Mobile banking and digital payments expand financial inclusion. High-speed internet fuels **e-commerce**, helping SMEs reach global markets and drive growth.



Economic Impact

Digitalization enhances efficiency through **Industry 4.0, AI, and automation**, optimizing production and minimizing downtime. **Cloud computing** improves flexibility and data protection, while **remote work** reduces commuting, boosting productivity and efficiency. Additionally, submarine cables facilitate **international connectivity**, driving business expansion.

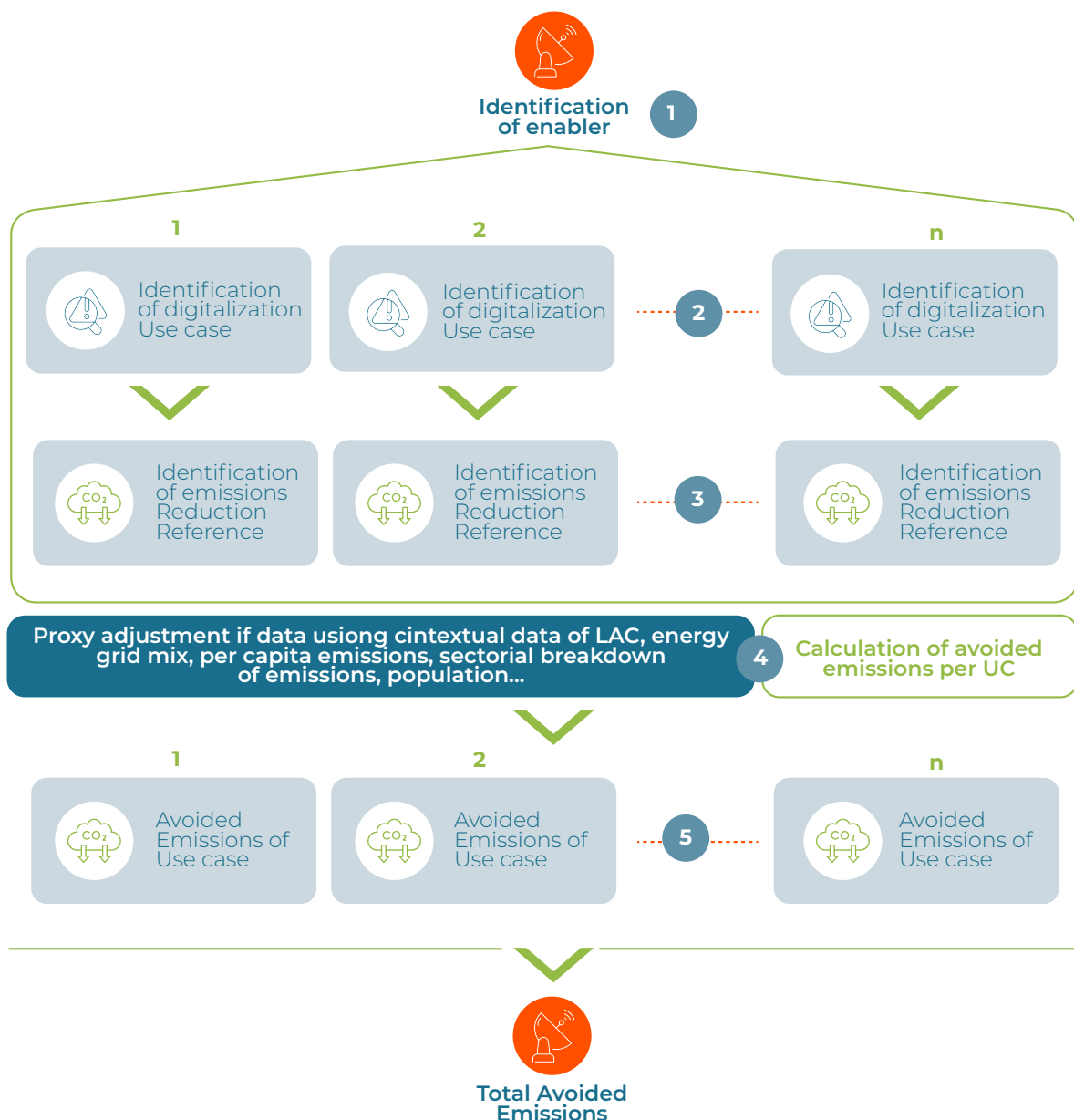


Environmental and Sustainability Impact

The expansion of telecommunications infrastructure **helps reduce GHG emissions** by enabling **sustainable digital solutions**. Smart cities use IoT and high-speed networks to optimize traffic, public transport, and air quality monitoring, improving urban sustainability. Energy efficiency in industries is enhanced through AI and Big Data, reducing consumption and waste. Additionally, sustainable data centers, powered by renewable energy, minimize the environmental footprint by replacing redundant physical infrastructure with cloudbased solutions.

Methodology

This methodology estimates GHG emissions savings from telecommunications infrastructure in the LAC region, using national and regional data. It calculates reduction factors for various digitalization measures, highlighting their impact in different contexts.



The methodology is fully **adaptable and flexible**, allowing for the calculation of emissions reductions in any chosen region by **adjusting the proxy values** accordingly. It can be customized to reflect **specific regional conditions**, including variations in energy mix, transportation patterns, and digitalization levels. This adaptability ensures that the **approach** remains relevant and **applicable** across **different contexts**.

01_ Identification of enabler

This step **identifies key telecommunications** infrastructures for investment, focusing on those in early deployment, undergoing upgrades, or improving efficiency. Sources such as scientific research, industry developments, and telecom operator reports are analyzed to pinpoint high-impact infrastructures for digitalization and emissions reduction. Examples include 5G expansion, the transition from copper to fiber-optic networks, and energy-efficient data centers.

02_ Identification of Digitalization Use Cases

Once the infrastructures are identified, the next step is **mapping the digitalization opportunities they enable across different industries**. Technologies like AI can optimize manufacturing, while advanced connectivity supports digital transformation in healthcare, transportation, and finance. This step analyzes industry trends and real-world applications to determine the most impactful digital solutions for sustainability and efficiency.

03_ Identification of Emission Reduction Reference

This phase assesses **how each digital use case contributes to emissions reduction** using sources like ESG reports, ITU, and GSMA. Since data is often presented in different formats (e.g., industry-wide reductions or country-specific CO₂ savings), adjustments are necessary to ensure relevance to the region of interest.

04_ Proxy Adjustment

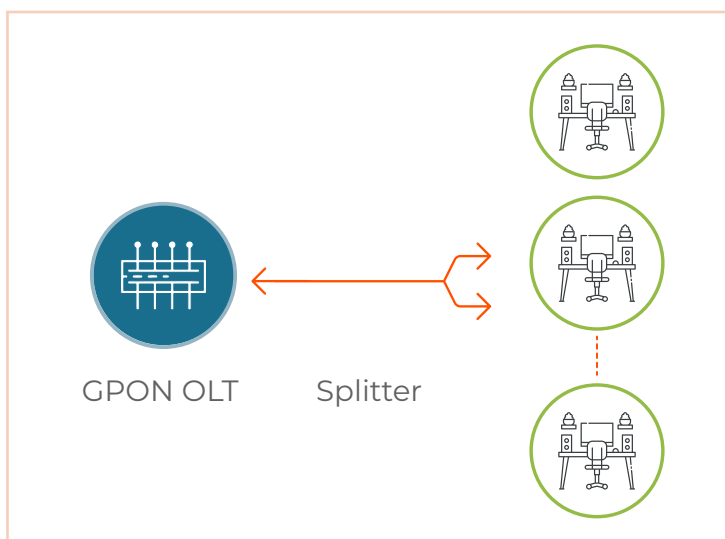
To produce realistic estimates, **emissions reduction data is adjusted based on regional factors** such as population size, per capita emissions, energy mix, and economic structure. This ensures that calculations accurately reflect the environmental and economic conditions of LAC.

05_ Sum of Avoided Emissions

Finally, the **emissions savings** from all digitalization use cases enabled by telecommunications infrastructure are aggregated. This provides a comprehensive assessment of the total emissions reduction potential, helping to measure the overall impact of digital transformation in the region.

01_ Identification of Enabler

The foundational **telecommunications solutions** that enable digitalization across industries are essential for fostering innovation, efficiency, and sustainability. These enablers provide the connectivity, computing power, and data exchange capabilities needed to accelerate digital transformation and **reduce GHG emissions**. This report identifies eight critical investment opportunities in the telecom sector that, individually or combined, create the digital environment necessary for widespread adoption of digitalization use cases.



Deployment of GPON

GPON is a high-speed fiber-optic technology that delivers internet, voice, and video over a scalable, cost-effective network with **higher bandwidth, lower latency, and greater reliability** than copperbased systems.

GPON is a fundamental enabler of reliable broadband connectivity, driving digital transformation across multiple sectors. By providing a robust and scalable fiber-optic

infrastructure, it facilitates the deployment of **innovative digital solutions that enhance efficiency**, connectivity, and automation. Its capabilities makes it a key component in the evolution of smart cities, modern businesses, and nextgeneration services, **leading to a significant advance in the reduction of GHG emissions**.

Some key digitalization opportunities enabled by GPON are:



Telemedicine



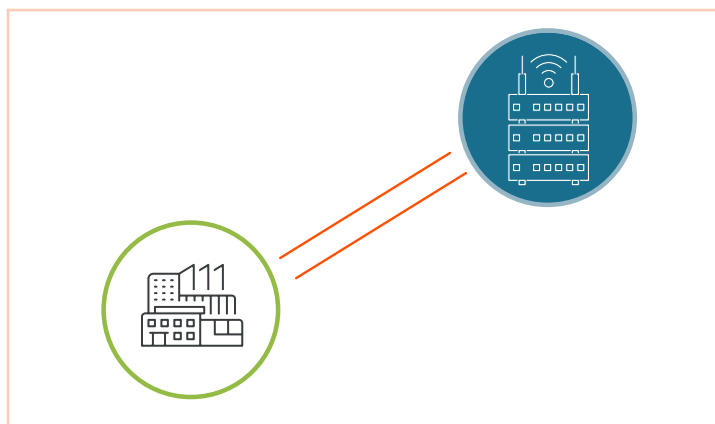
Remote Work



Smart homes



Cloud apps



Dedicated Fiber Lines for Companies

Dedicated fiber lines provide high-speed, secure, and private internet access for businesses, ensuring symmetrical speeds, minimal latency, and high bandwidth. Essential for industries requiring strong cybersecurity. It enhances enterprise connectivity, real-time data processing, and inter-office communication, driving **operational efficiency**.

It enables ERP systems and adoption of emerging technologies that **can reduce GHG emissions**. Some key digitalization opportunities enabled by Dedicated fiber lines are:



Industry 4.0



Smart Shipping



E-Banking

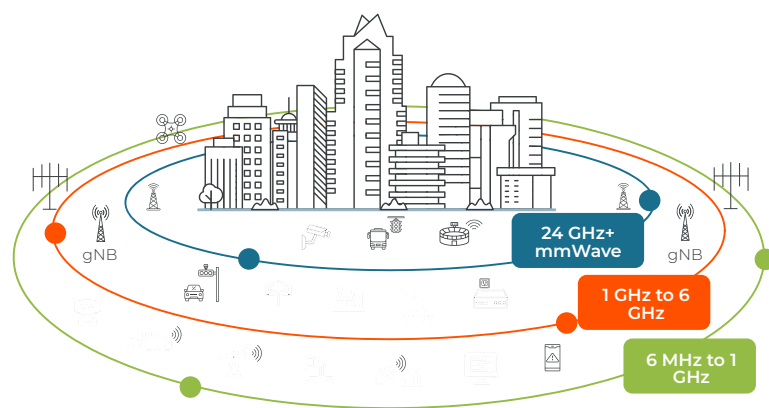


Virtualization

Deployment of 5G Networks

5G is a next-generation mobile network technology that delivers **high-speed, lowlatency, and ultra-reliable connectivity**.

It enables seamless communication between devices, supports massive IoT deployments, and expands broadband access to rural and remote areas. Its advanced capabilities facilitate real-time data transmission, automation, and AI-driven applications across various industries.



5G is a critical enabler of digital transformation and emission savings by enhancing connectivity and **optimizing energy efficiency** across sectors. It reduces the need for physical travel, supports remote operations, and enables smart city solutions, industrial automation, and **intelligent energy management**. By powering data-driven decision-making and IoT applications, 5G contributes to **lower carbon footprints and more sustainable business practices**.

Some key digitalization opportunities enabled by 5G Networks are:



Smart Cities



Industrial Automation



Telemedicine

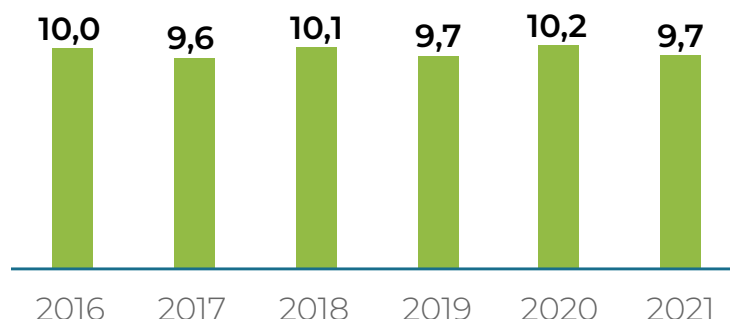


Virtualization

Funding of Smartphones

Smartphones are key enablers of digital transformation, providing individuals with **access to mobile banking, e-commerce, elearning, telemedicine, and remote work opportunities**. By serving as the primary gateway to the internet, particularly in developing regions, smartphones facilitate socioeconomic inclusion, digital services adoption, and connectivity in areas with limited infrastructure.

Affordability (%) of an entry-level internet-enabled handset in LMICs⁷⁵



Smartphone adoption significantly **contributes to emission savings** by replacing resource-intensive activities such as excessive paper use, unnecessary travel, and inefficient processes with digital alternatives. These devices support **sustainable solutions** like telemedicine, online education, and remote work, reducing carbon footprints across sectors. Additionally, mobile-enabled smart agriculture and collaborative economy platforms **enhance resource efficiency and sustainability**.

Some key digitalization opportunities enabled by Funding of Smartphones are:



Digital Transactions



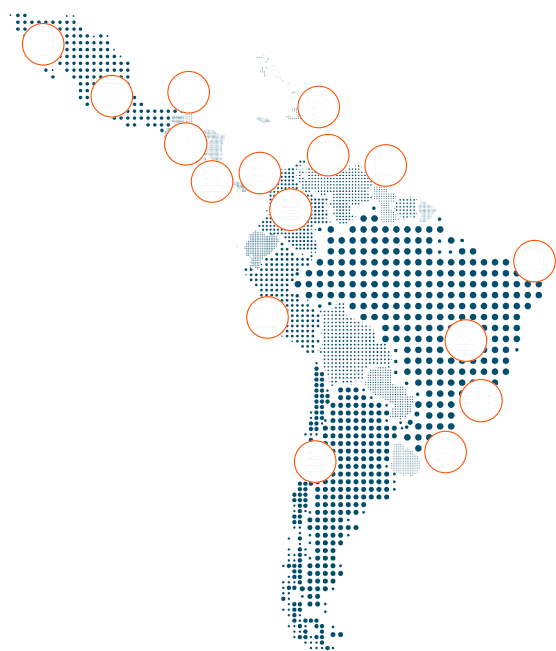
E-learning Digital



Marketplaces



Workforce Empowerment



Deployment of Data Centers

Data centers are the **backbone of the digital economy**, enabling cloud computing, AI, big data, and digital services across industries. Their deployment enhances connectivity, computational power, and data security, supporting businesses, governments, and individuals in areas like e-commerce, finance, healthcare, and smart city infrastructure. By facilitating cloud computing, data centers allow companies to shift from traditional onpremises IT to scalable, cost-effective cloud solutions, improving efficiency and reducing capital expenditures.

These facilities drive innovation while **promoting sustainability** by optimizing server utilization and **integrating renewable energy**. Cloud-based data storage reduces energy consumption compared to traditional systems, supporting advancements like sustainable streaming, blockchain, and big data applications. Investing in green data centers helps businesses lower operational costs while aligning with **global carbon neutrality** targets, ensuring regulatory compliance and a **greener digital future**.

Some key digitalization opportunities enabled by Data Centers are:



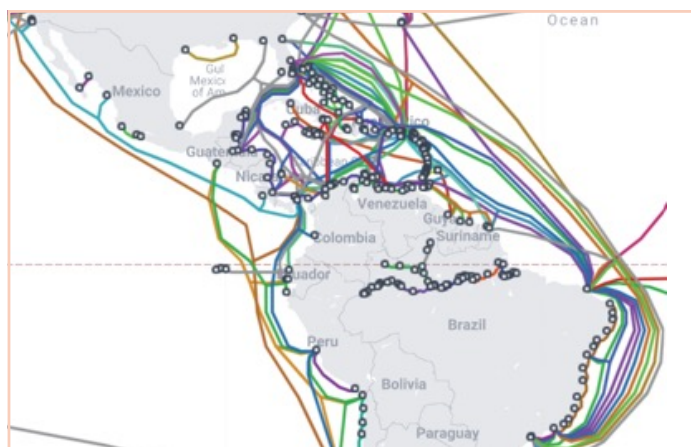
Software as a Service (SaaS)



Blockchain



Big Data



Deployment of International Networks

Global connectivity networks, including submarine cables and Internet Exchange Points (IXPs), are fundamental to digital infrastructure, ensuring high-speed, reliable data transfer across continents.

Submarine cables handle over 99% of intercontinental data traffic, linking data centers, cloud providers, and enterprises,

while IXPs optimize regional internet traffic by facilitating local data exchanges, reducing latency, and improving network resilience.

These infrastructures enable digitalization in remote and emerging regions, **reducing emissions** by promoting virtual education, financial inclusion, and e-commerce, minimizing physical travel and inefficient supply chains. Additionally, they **support climate action** by enabling satellite-based environmental monitoring, optimizing energy efficiency in data transmission, and fostering smart city innovations that contribute to **sustainability**.

Some key digitalization opportunities enabled by Data Centers are:



Smart Infrastructure



Digital Sovereignty



Environmental Monitoring

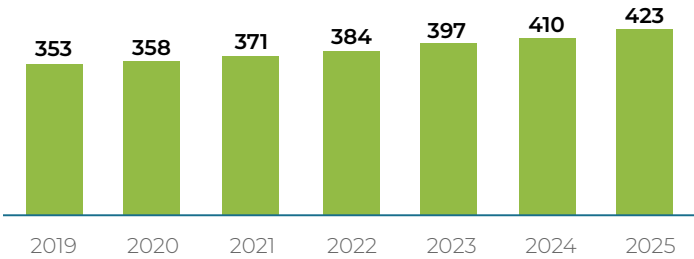


Cloud Services

Financing Unlimited Data Plans

Unlimited data plans promote greater cell phone usage, enabling remote work, virtual meetings, and online education, which reduce the need for travel and lower transportation-related GHG emissions. Additionally, they support the **expansion of digital services and smart technologies**, such as cloud computing, IoT devices, and smart city infrastructure, optimizing energy use and improving efficiency across multiple sectors.

Mobile Internet Users per Year in LAC (millions)



Financing unlimited data plans accelerates digital transformation by **increasing demand for mobile and fixed networks**, fostering the deployment of technologies like 5G and GPON. This measure enhances connectivity, encouraging the **adoption of digital services and sustainable practices** that contribute to emissions reduction and smarter resource management.

Some key digitalization opportunities enabled by Unlimited data plans are:



Telemedicine



Remote Work



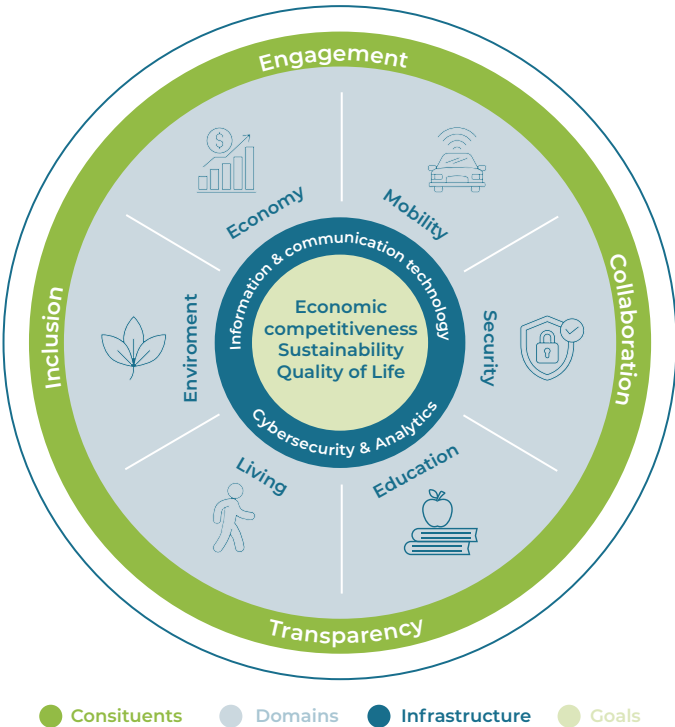
E-commerce



E-Banking

Smart Cities

Smart cities leverage advanced telecommunications infrastructure to **enhance urban management, improve efficiency, and reduce emissions**. By integrating IoT devices, AI, and real-time data collection, these cities optimize mobility, energy use, waste management, and public services. Intelligent traffic management systems analyze data from connected vehicles and smart signals to ease congestion and lower fuel consumption, directly **reducing CO2 emissions**. Smart grids, supported by fiber-optic and wireless networks, enhance electricity distribution, facilitate renewable energy integration, and implement demand response mechanisms to minimize waste.



A strong telecommunications infrastructure is essential for smart cities, enabling real-time data analytics and IoT applications. Deployments such as 5G small-cells, fiber-optic network, and smart antennas embedded in urban infrastructure improve connectivity, supporting innovations like smart parking and **optimized waste collection, which reduce fuel consumption** and operational costs.

Some key digitalization opportunities enabled by Smart Cities:



Mobile Banking



Smart Transport



Smart Home



Ridesharing

02_ Digitalization Use Cases

The deployment of telecommunications infrastructure is the foundation for digital transformation across multiple sectors, driving efficiency, resource optimization, and sustainability. This section identifies some **key digitalization use cases powered by these infrastructures and assesses their potential to reduce GHG emissions**. In this section, a few digitalization use cases are described for illustrative purposes, a total of 26 are listed in Annexes and matched with the telecommunications investment that enables them.

Financing Unlimited Data Plans

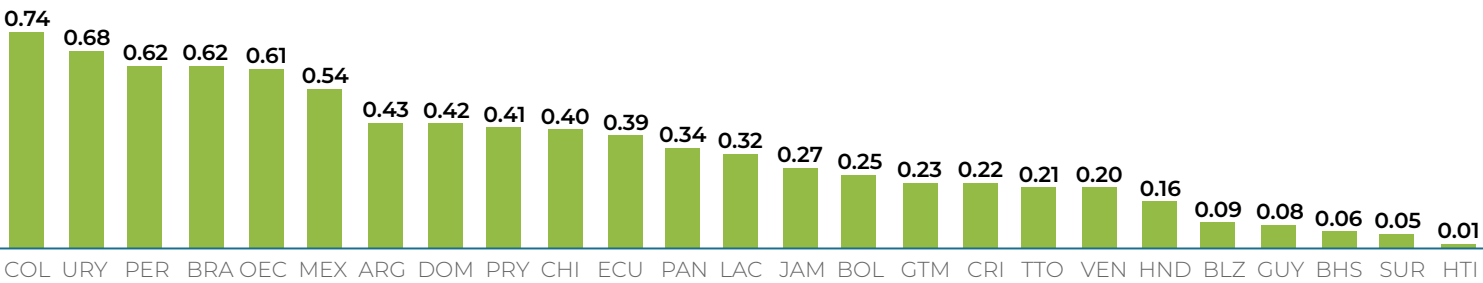
Telework reduces commuting and lowers GHG emissions through video conferencing, cloud apps, and VPNs. One remote workday per week can cut household emissions by 4.9 kgCO₂⁷⁶. A Dell Program in Utah saved millions and cut 1.3 tons of CO₂ ⁷⁷ monthly.



Digitalization of Government Services

The digitalization of government services allow citizens to complete tasks like tax filings and permit applications online, reducing paper use and transport-related emissions. A study⁷⁸ of 226 Chinese cities (2012–2016) found that a 1% increase in e-government development correlated with a 6.71% drop in PM2.5 levels. Haiti, the Bahamas, Suriname, and Belize have the most development potential.

2023 OECD - IDB Digital Government Index⁷⁹



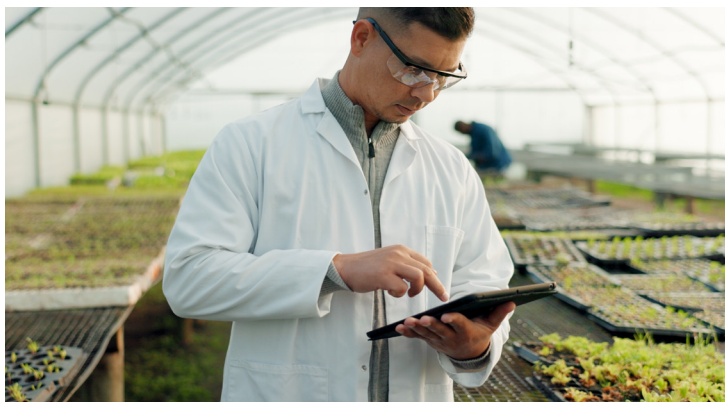
Telemedicine & Virtual Healthcare

Telemedicine enables remote consultations, diagnostics, and health monitoring, reducing patient travel and hospital resource use while improving access to healthcare, especially in rural areas. Carbon savings per consultation range from 0.70 to 372 kg CO₂e ⁸⁰, with telemedicine's own emissions being negligible.



Smart Home Energy Management

High connectivity allows smart home systems to optimize energy use by controlling lighting, heating, and appliances in real time. Alpowered thermostats like Google Nest and Ecobee adjust temperatures efficiently, reducing unnecessary energy consumption. The U.S. Department of Energy estimates that smart thermostats cut household energy use by 10-15%⁸¹, significantly lowering CO₂ emissions from heating and cooling.



Smart Agriculture

Smart agriculture integrates IoT, AI, and big data to optimize farming, reduce emissions, and improve efficiency. In California, solar-powered soil sensors cut irrigation water use by 6% and GHG emissions by 5%⁸². In China, IoT-enabled greenhouses led to a 100% yield increase, a 50% reduction in water and fertilizer use, and a 75%⁸³ profit boost. Additionally, drones enhance sustainability by mapping soil, optimizing crop inputs, and aiding reforestation—each drone can plant a hectare in 20 minutes, supporting global efforts to restore 250 million hectares by 2030⁸⁴.

E-Banking

E-banking minimizes physical branch visits, reducing vehicle emissions, and cuts paper use by digitizing transactions. By lowering the energy consumption of bank branches and promoting digital payments, it decreases reliance on cash logistics. In Latin America, mobile banking can reduce emissions by 20.8kg CO₂ per smartphone⁸⁷, primarily by eliminating travel and paper-based transactions. Digital banking fosters sustainability while enhancing efficiency in financial services.



Ride Sharing

Ridesharing leverages GPS, cloud computing, and digital payments to optimize routes, reduce costs, and lower emissions, with 5G enhancing efficiency and supporting electric and autonomous vehicles. In China, Mobike's dockless bike-sharing service cut 1.2 million tons of CO₂ in its first year—equivalent to removing 350,000 cars. Expanding to 500 cities could save 30-60 million tons more⁸⁵. In Beijing, carpooling reduces CO₂ emissions by 46.2 thousand tons annually⁸⁶, highlighting the environmental impact of shared mobility solutions.



Autonomous Vehicles

Autonomous vehicles rely on sensors, AI, and real-time data processing to navigate without human intervention, enhancing safety and efficiency. Their development depends on 5G connectivity, which enables low-latency communication between vehicles and infrastructure, improving traffic coordination and reducing accidents. By integrating these technologies, autonomous electric vehicles could play a key role in sustainability, with projections estimating a 34%⁸⁸ reduction in transportation-related GHG emissions by 2050



03_ Identification of Emissions Reduction References

After identifying digitalization opportunities, the third step involves assessing the potential emissions savings these opportunities can provide within relevant industries or sectors.

This stage of the methodology **involves indepth research using global reports from sources such as ESG reports** from telecommunications operators, the International Telecommunication Union (ITU), the Global System for Mobile Communications Association (GSMA), and other relevant organizations. However, the data from these sources is not always directly applicable, as it may be presented in different formats, such as industry-wide emission reduction percentages or specific CO2 savings for a particular country.

To ensure relevance in the LAC context, this data often requires further adaptation. This adaptation is carried out in step 4.

GSMA™



statista

TeleGeography

These references may be presented as a percentage of emissions reduction in a specific sector, CO2 savings in kilograms or tons, emissions reduction per household, emissions reduction per avoided trip, or in other formats. Some of the references obtained in this work are:



Reduction in carbon emissions by using AR in online shopping -> 46% ⁸⁹



Reduction due to virtual healthcare per consultation -> 0,7 – 372 kg CO2 ⁹⁰



Reduction due to Smart Home Energy Management Systems -> 10 – 15% ⁹¹



Reduction due to server virtualization -> 63% compared to physical servers⁹²



Reduction in manufacture due to the use of IoT -> 34 – 50% ⁹³



Reduction due to the use of Digital Twins -> 15% ⁹⁴



Reduction due to Smart Agriculture -> 5% ⁹⁵

04_ Proxy Adjustment

This step **refines emission reduction data to better reflect the specific conditions of the LAC region**, its countries and regional context. It requires comprehensive contextual data, including population size, per capita emissions, sectoral emissions distribution, energy mix, and other relevant factors.

By integrating and combining these variables, the **methodology ensures a more accurate assessment of emissions savings** aligned with LAC's environmental, economic, and social landscape. In this section, some of the data used in the proxy is provided and explained.



Emissions per capita

Considering regional per capita emissions ensures accurate emission reduction estimates by reflecting industry structures, and consumption patterns. This adjustment enhances the relevance and effectiveness of mitigation efforts within the specific environmental and economic context.

6,33 tons/year in LAC⁹⁶

Emissions per sector

Adjusting emissions from a reference sector to another is crucial to account for differences in energy use, efficiency levels, and operational practices. This ensures a more accurate assessment of emission reduction potential when applying data from one sector to another.

1,9 Gtons/year in LAC Energy Sector⁹⁷

Percentage of companies using servers

Knowing the percentage of companies using servers is crucial, as the potential for emission savings through cloud computing depends on the country's level of digitalization. Countries with greater reliance on traditional servers have greater opportunities for reducing GHG emissions by adopting cloud-based solutions.

24% in LAC⁹⁸



Sum of Avoided Emissions

In this step, emissions savings from each digital use case are initially kept separate to provide a detailed and granular view of the impact of each specific initiative. However, to determine the total emissions reduction potential of the telecommunications infrastructure, it is necessary to aggregate the emissions savings associated with all use cases that the infrastructure enables. By summing these individual reductions, a more comprehensive and accurate assessment of the infrastructure's overall potential for emissions savings is obtained at a regional level.

Σ Emissions reduction



Example of the Methodology Deployment of GPON

The first two steps of the methodology, identifying connectivity enablers and the digitalization opportunities they support, have been outlined in steps 1 and 2. Building on this groundwork, the next step is to quantify the reduction in GHG emissions resulting from the deployment of GPON infrastructure in the LAC region.

This analysis assumes that GPON facilitates digitalization across multiple sectors. However, to illustrate the methodology, only two specific opportunities will be examined in detail. While GPON supports a wider range of digital initiatives, these examples highlight its role in estimating the environmental benefits of telecom infrastructure deployment.

Remote work

8k CO₂
per household in EU

This analysis begins by identifying a reliable reference for emissions savings from teleworking. A source indicates that one day of remote work per week in the EU reduces CO₂ emissions by 3.1 kg per household in winter and 4.9 kg in summer, totaling an annual reduction of 8 kg of CO₂ per household.

To adjust the reference for LAC, the total number of households must be estimated. Since direct data is unavailable, an average household size of 3 people was derived from Brazil, Colombia, and Mexico. Dividing LAC's total population by this figure results in an estimated 212.774.621 households, based on Statista data.



Households of LAC = Households of Brz, Mex, Col * $\frac{\text{Population of LAC}}{\text{Population of Brz, Mex, Col}}$

Since household emissions are influenced by household size, a coefficient must be calculated to adjust for differences between LAC and the EU. LAC’s estimated household size is 3 people, while the EU’s is 2.3⁹⁹, meaning LAC households have 0.7 more people on average.

= $\frac{\text{LAC Household size}}{\text{LAC Population}}$

LAC Households

To ensure accurate regional adaptation, per capita emissions differences between LAC and the EU must also be considered. With per capita emissions of 7.25 tons CO₂ in the EU and 6.33 tons CO₂ in LAC 100,101, a ratio is calculated to scale the EU reference data appropriately. Using this adjustment, the total emissions reduction potential of enabling one day of remote work per week across LAC is then estimated.

Total Emission Reduction = $\frac{\text{Emissions reduction household EU * LAC household size *}}{\text{LAC per capita emissions}}$

EU household size + EU per capita emissions

5,8M tons CO₂
per year avoided in LAC

Telemedicine & Virtual Healthcare

To estimate GHG emissions reductions from virtual medical consultations, a reference value is needed. In the UK, telemedicine consultations have been shown to cut emissions by 0.7 kg to 40102 kg of CO₂ per visit, depending on factors like travel distance avoided and logistical efficiencies.

0,7 - 40kg
CO₂ per visit in UK

To establish a benchmark for emissions savings, the average reduction per virtual consultation is calculated at 10 kg of CO₂. Next, the methodology considers telemedicine adoption in LAC, with projections indicating that by 2029, 1.75%¹⁰³ of the population will have access to these services.

4,5kg
CO₂ per household in UK

Before applying this projection, the emissions reduction data must be adjusted for regional differences in per capita CO₂ emissions. With the UK at 4.5 metric tons per year and LAC at 6.33 metric tons, this ensures the estimate accounts for the region's energy mix and transportation emissions.

We also factor in the total LAC population and the estimated average of 2.35¹⁰⁴ doctor visits per person per year. Using these values, the following formula calculates the total annual emissions reduction from telemedicine in LAC by 2029, assuming GPON fiber deployment.

$$\text{Total Emission Reduction} = \frac{\text{Consultations} * \text{LAC Population} * \text{Penetration} * \text{Reduction} * \text{LAC emissions per capita}}{\text{Emissions per capita in UK}}$$

0,37M
tons CO₂ per year avoided in LAC

Total reduction

The total reduction in emissions enabled by the deployment of GPON is the sum of the individual reductions achieved through each digitalization opportunity. This highlights the substantial environmental impact that expanding GPON fiber infrastructure can facilitate.

6,2M
tons CO₂ per visit in UK

Annexes

Annex 1 – Enablers & Effects

This mapping explores the connection between telecommunications infrastructure and digitalization use cases, emphasizing that many use cases rely on multiple infrastructures working together. For example, online banking is made possible by smartphones for user access but also depends on fiber-optic connections to ensure secure and stable service. This interdependence underscores the need for a comprehensive approach when assessing how telecommunications infrastructure drives digital transformation across various sectors. The table shows the digitalization use cases explored in this study, but there is an infinite range of use cases.

Due to the format of the table the following list acts as a legend:

1.- GPON. **2.-** Dedicated Fiber Lines. **3.-** Deployment of 5G Networks. **4.-** Funding of Smartphones. **5.-** Deployment of Data Centers. **6.-** Deployment of International Networks. **7.-** Funding of Unlimited Data Plans. **8.-** Smart Cities.

	1	2	3	4	5	6	7	8
Remote Work and Distance Education	X	X	X	X	X		X	X
Digitalization of Government Services		X		X	X			X
E-Commerce and Augmented Reality Shopping	X		X	X			X	X
Telemedicine and Virtual Healthcare Appointments	X		X	X	X	X	X	X
Smart Home Energy Management Systems	X			X				X
Cloud Computing and Virtualization		X	X		X	X		
Enhanced Energy Management Through IoT	X	X	X	X	X			X
Implementation of Industry 4.0		X	X		X	X		
Creation of Virtual Networks and Device Softwarization		X	X		X	X		
Smart Agriculture			X	X				X
Smart Transport			X	X	X	X		X
Autonomous Vehicle			X	X	X		X	X
Mobile Banking and Digital Payments			X	X	X		X	X

Understanding the interdependence between telecommunications infrastructure and digital use cases is essential for accurately evaluating their role in enabling digital transformation. A comprehensive approach ensures that investments in infrastructure align with the broader goal of enhancing connectivity and sustainability across sectors.

Due to the format of the table the following list acts as a legend:

1.- GPON. **2.-** Dedicated Fiber Lines. **3.-** Deployment of 5G Networks. **4.-** Funding of Smartphones. **5.-** Deployment of Data Centers. **6.-** Deployment of International Networks. **7.-** Funding of Unlimited Data Plans. **8.-** Smart Cities.

	1	2	3	4	5	6	7	8
Collaborative Economy Platforms Like Carsharing and Bikesharing		X	X	X	X		X	X
Cloud Computing for Business and Governments		X			X	X		
Sustainable Blockchain Systems for Industrial Traceability		X			X	X		X
Access to Digital Education in Rural Areas			X	X		X		
Maritime Logistics and Smart Shipping		X			X	X		
Climate and Biodiversity Monitoring via Satellites			X			X		
Digital Enablement via Submarine Cable		X			X	X		
E-Banking		X	X	X	X	X		X
RideSharing	X		X		X		X	X
Smart Traffic Management			X	X	X		X	X
Smart Waste Management			X	X	X			X
Policy Making through Digital Tools	X	X	X	X	X	X	X	X
Smart Building Sector		X	X	X	X			X

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