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in Latin America and the Caribbean

The role of resilient infrastructure investments and adaptation policy

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The role of resilient infrastructure investments and adaptation policy

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Content

Abstract

The objective of this article is to analyze the impact of climate events in Latin America and the Caribbean on people and the economy from a historical and prospective perspective. First, the region experienced at least 2,225 climate-related disasters that caused damages and losses of 0.2% of the annual GDP and affected 1% of the region's population on average per year in the past 4 decades. However, these events affected twice as many people in Central America and three times in the Caribbean compared to the regional average. Second, the article explores the effects of increased exposure to disasters compared to policy alternatives to reduce vulnerability. We used a quantitative general equilibrium model with climate shocks applied to four of the most vulnerable economies to climate-related disasters in the region (Honduras, Dominican Republic, Barbados, and Paraguay) for the analysis. The results suggest that investing in resilient infrastructure and creating contingency funds significantly reduces the impact of these events on GDP and improves public debt dynamics in the medium and long term. Nonetheless, both investment in resilient infrastructure and the inception of emergency funds erode debt dynamics in the short term. Consequently, mobilizing resources and concessional financing will be important for facilitating investments in adaptation. Financing on favorable terms would be particularly useful for preventing suboptimal levels of investment for both highly indebted countries that face restrictions on access to financing and for mitigating inter-temporal inconsistency problems.

1 Introduction

Global surface temperature has increased by about 1 °C since 1850. The effects of a rapidly changing climate are generating an increase in the frequency of most hydro-meteorological events and creating a landscape of complex and, at times, interconnected hazards.[1] Heat waves, droughts, and heavy precipitation now occur 2.8, 1.7, and 1.3 times more frequently, respectively, compared to a climate without human influence. If temperatures continue to rise, these extreme events will become even more frequent (IPCC, 2021 and 2022).

Latin America and the Caribbean is one of the most exposed regions in the world to climate change due to its geographic location (closer to the tropics) and its higher average temperatures. During the last 43 years, at least 2,225 climate-related disasters have been registered in the region, which are equivalent to an average of 52 events per year. Floods and storms are the most frequent events (49.5% and 30.6% respectively of all events) followed by landslides (7.0%) and drought (6.9%). In addition, the number of extreme events in the region rose 90% between 2000 and 2021 with respect to the previous two decades (Brassiolo et al, 2023). Moreover, many conditions of vulnerability are prevalent in the region, increasing the risk of suffering severe impacts derived from climate events.

Indeed, climate-related disasters have caused significant damage and economic losses and affected a high percentage of the population. It is estimated that, on average, annual damages and losses in the region have been at least 0.2% of GDP. Furthermore, about 1% of the region's population, on average, is affected by climatic disasters each year, and the aggregate number of deaths and missing persons is estimated to be close to 100,000 people. For example, the disasters associated with the last three major El Niño events in 1982-1983, 1997-1998, and 2014-2016 caused damages in Chile, Colombia, Peru, and Ecuador that were estimated at USD 6.473 billion and more than 3,300 deaths (ECLAC, 2010 and 2023). The current drought in the southern part of the continent could cost between 2% and 5% of GDP in Argentina, Brazil, Paraguay, and Uruguay (CAF, 2023).

1. "According to the U.S. Geological Survey (USGS), climate change contributes to natural disasters via three mechanisms. First, rising global temperatures increase the likelihood of droughts and the strength of storms. Second, high levels of atmospheric water vapor create the energy needed for more intense storms to develop. Third, the combination of atmospheric heat and warmer ocean temperatures contributes to increased wind speeds in tropical storms" (Naoaj, 2023).

The negative impacts of these events on economic growth may be permanent, particularly in developing countries. For example, climate-related disasters may have caused permanent losses of between 2.1% and 3.7% of GDP in low- and middle-income countries (Cavallo et al., 2022). However, the evidence for long-term economic consequences is not generally robust, especially when country-level data are analyzed (Noy and duPont, 2018) possibly because higher-income economies are less vulnerable.[2]

This article aims to analyze the impact of climate events in Latin America and the Caribbean on people and the economy from a historical and prospective perspective. To this end, we evaluate the effects of increased exposure to extreme climate events, considering alternative policy options to reduce vulnerability, such as investing in resilient infrastructure and creating contingency funds. Based on these findings, policy recommendations for reinforcing adaptation initiatives in the region to manage climate risks are proposed.

2. However, there are notable exceptions among poor countries and small island nations that have been less resilient to natural disasters in the long term. Country studies have found evidence of permanent socioeconomic effects such as migration, income losses, falls in asset prices, and permanent changes in the sectoral structure of economic activity.

For this analysis, we use a quantitative general equilibrium model with climate shocks applied to four of the region's most vulnerable economies to climate-related disasters (Honduras, Dominican Republic, Barbados, and Paraguay). The results suggest that investing in resilient infrastructure significantly reduces the impact of these events on GDP and improves the trajectory of public debt in the medium and long term. The effect on the debt dynamics is reinforced if, in addition to investment in resilient infrastructure, a contingency fund is established to address emergencies associated with disasters. However, both the investment in resilient infrastructure and the creation of an emergency fund negatively impact the debt dynamics in the short term. When there are financial frictions or inter-temporal inconsistency problems, the cost of investments in the short term could result in suboptimal resource allocation decisions with negative consequences for growth and fiscal performance in the long term.

Both the investment in resilient infrastructure and the creation of an emergency fund negatively impact the debt dynamics in the short term.

Note that these results assume full or partial concessional financing for investment in resilient infrastructure.[3] Quantitative analysis shows that financing these investments exclusively with non-concessional loans could worsen debt dynamics in the short and medium term compared to a no investment scenario. If a climate-related disaster occurs, having resilient infrastructure would reduce the adverse impact on capital and output.

Favorable financial conditions thus have a crucial role in mitigating problems of access to credit –especially for highly indebted economies with little fiscal space– or political economy issues, paving the way for facilitating investments in resilient infrastructure. These are estimated to require between USD 9 billion and USD 31 billion in funding per year across the region. This is equivalent to between 0.15% and 0.5% of GDP per year.[4] In the absence of these investments, the occurrence of a disaster could unleash a vicious circle characterized by an increasing debt trajectory that would raise borrowing costs, limit the possibilities for investment in resilient infrastructure and thus exacerbate the negative impact on production with a declining ability to respond.

3. As will become clear later, these quantitative exercises assume that countries will finance resilient infrastructure investment as well as that of the contingency fund with concessional debt, i.e., debt on much more favorable financial terms compared to what they can raise on the international markets.

4. This cost is calculated based on the assumption that there will be an annual investment in infrastructure of 5% of the GDP, which is the level required for the region to meet the Sustainable Development Goals (Galindo et al., 2022). In the last few years, however, the level of infrastructure investment in the region has been below 3% of the GDP per year on average (Serebrisky et al., 2020; Serebrisky et al., 2015). In other words, the total requirement for funds to both bring infrastructure investment to the aforementioned 5% of the GDP and make it more resilient amounts to approximately 2.5% of the GDP per year (USD 156 billion in 2022). To get an idea of how much could be financed on a concessional basis, it is useful to consider the fact that the World Bank, IDB, and the CAF grant loans of between USD 40 and 45 billion per year (Galindo et al., 2022).

The results therefore point to the need for greater investment in climate risk reduction as a supplement to climate disaster preparedness and response. In addition, the study suggests that continued adaptation is essential to reducing vulnerability to extreme weather events that could increase in intensity in the future. Although the model used in this note only allows us to evaluate the impact of investment in resilient infrastructure and the creation of funds to address climate emergencies, other alternatives for intervention that target different drivers of country vulnerability such as territorial planning and nature-based solutions for reducing the vulnerability of countries to climate risks should be considered.

The study suggests that continued adaptation is essential to reducing vulnerability to extreme weather events that could increase in intensity in the future.

The results also underscore the importance of support from multilateral banks as allies of the countries in the region to both: mobilize capital and provide concessional financing, so that the countries can carry out the investments in resilient infrastructure that are needed to adapt to, and manage, climate risks.

This note has four sections including this introduction. Section 2 defines the main climatic events that affect the region and outlines the human and economic costs of the disasters that occurred between 1980 and 2023 based on the information contained in EM-DAT. In section 3, the potential impacts of an increase in the severity and frequency of extreme weather events on economic growth and public debt trends in some of the most vulnerable countries in the region are investigated. In section 4, by way of conclusion, the main policy recommendations based on the findings of the previous two sections are summarized.

2 Climate events: occurrence and impacts in Latin America and the Caribbean

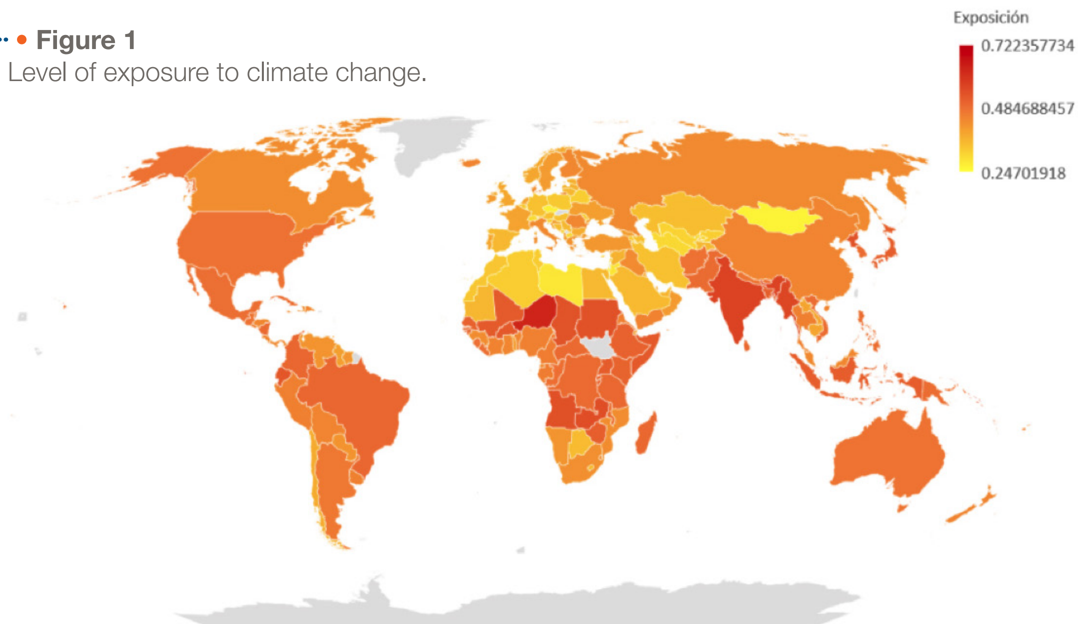
The incidence and impacts of the main climate events documented in Latin America and the Caribbean between 1980 and 2023 are analyzed in this section. First, the conditions of climate disaster risks are defined and a typology of the most common types of events in the region and the impacts they usually generate is presented. Second, an analysis is done of the general impacts of disasters, and the types of events that generate the greatest damage and losses are highlighted. Finally, the exposure of the different subregions of Latin America and the Caribbean to different types of climate events is evaluated.

Latin America and the Caribbean is a region that is exposed to climate change and one where many conditions of vulnerability are prevalent. The risks of suffering economic and human damage and losses from extreme weather events are determined by the degree of exposure as well as by the vulnerability of countries to these hazards.[5]

First, some regions around the world are more prone or exposed than others to the occurrence of extreme weather events (Figure 1). In general, regions near the equator tend to be more exposed than temperate zones. An example of this are tropical storms and hurricanes that are highly destructive events and can cause substantial damage to infrastructure (housing, roads, energy, etc.). The Caribbean and Central America are more exposed to these types of events than other regions of the continent. Droughts, which are more prevalent in the southern part of the continent and in the Central American Dry Corridor, do not usually cause damage to physical infrastructure, but they generate significant losses in agricultural production and hydroelectric power generation which affects economic activity and food security for the most vulnerable.

5. Exposure captures the degree to which a system is exposed to significant climatic variations. Vulnerability, in turn, refers to the degree to which the system is susceptible to the adverse effects of climate change and its capacity to cope with them.

Figure 1
Level of exposure to climate change.



Note: Darker colors mean a higher level of exposure.
Source: Prepared by the authors based on ND-GAIN (University of Notre Dame Global Adaptation Initiative).

Secondly, various country-specific conditions determine how vulnerable a country may be to the effects of climate threats. A climate event of the same intensity could generate a more negative economic and social impact depending on the quality of the infrastructure, land-use planning, the ability to react to the emergency, population's level of poverty, the type of economic activity prevailing in the affected area, among others.

Vulnerability to climate threats is strongly related to the degree of economic development (IMF, 2019 IPCC, 2022). The resilience of infrastructure, the quality of governance, the incidence of poverty and inequality, the degree of financial inclusion and the efficiency of the insurance market affect the countries' ability[6] to adapt to climate problems and cope with extreme weather events (Bellon and Massetti, 2022). Damage to infrastructure due to climate-induced disasters can impact the performance of economic activity and people's well-being by disrupting access to goods and services (health, education, electricity, food) or forcing them to select from suboptimal supplies (Hallgate et al., 2019). This could end up limiting the opportunities for equitable and sustainable development. https://www.imf.org/en/Publications/Policy-Papers/Issues/2019/06/24/Building-Resilience-in-Developing-Countries-Vulnerable-to-Large-Natural-Disasters-47020. Within countries, lower-income households are also more vulnerable to climate events. The most disadvantaged households lose a greater share of their wealth when disasters occur if their homes, which are often their main asset, are affected, and they have less access to financial resources and sources of insurance to cope with emergencies (Hallegatte and Rozenberg, 2017; CAF, 2022).

6. Adaptive capacity refers to society's ability to adapt to climate change and cope with the consequences of its impact.

The economic structure of countries can increase vulnerability to extreme weather events. The high economic weight that climate-sensitive sectors such as agriculture, forestry, fisheries, water or hydropower have, for example, exposes countries more to disasters associated with higher temperatures and more frequent extreme events (Bellon and Massetti, 2022). Some sectoral development strategies also contribute to increasing vulnerability. For example, the development of infrastructure for tourism in hazard-prone coastal areas, water-intensive agriculture in arid or semi-arid lands, the transformation of vegetation cover in areas prone to landslides or floods, and other activities that tend to degrade ecosystems. The dependence of the Caribbean and Central America on tourism and agriculture makes these regions more vulnerable to damage and losses associated with disasters.

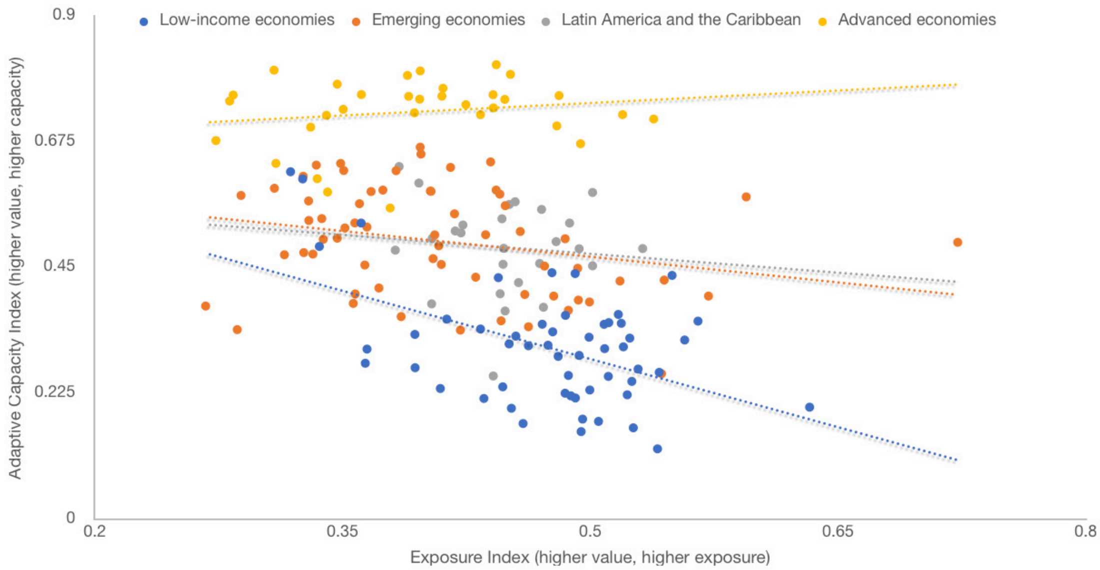
In general, Latin American and Caribbean countries face greater risks from climate hazards than advanced economies.

Another important aspect that affects vulnerability to extreme climate events is the laxity in the countries' fiscal and financial situation. For example, there are countries in the Caribbean and Central America that are highly exposed to climate events but have not invested enough to improve their ex ante resilience. Investment in resilient infrastructure has been displaced by the urgency of addressing other social objectives in the context of the constraints of tight fiscal margins (IMF, 2021). This could lead to a vicious cycle where governments end up spending large unbudgeted sums to respond to the climate emergency and on the efforts to rebuild after a disaster. This would result in higher indebtedness and a deterioration in fiscal accounts.[7] As a result, the countries in the region that are most vulnerable to disasters may have a worse fiscal performance, and this could worsen the credit conditions for investing in adaptation projects (Cavallo et al., 2023; Cárdenas, 2023).

In general, Latin American and Caribbean countries face greater risks from climate hazards than advanced economies. While advanced economies stand out for their lower vulnerability, lower-income economies in general tend to have higher exposure with much lower adaptive capacity and, therefore, higher vulnerability (Figure 1). Although most Latin American countries are better able to adapt to climate change than the average emerging and low-income economies, many countries in the Caribbean and

7. For example, Dominica was affected in 2017 by Hurricane Maria with losses and damages equivalent to 227% of the GDP, particularly in housing infrastructure due to deficiencies in its resilience. This will tremendously affect fiscal accounts for years to come (World Bank, 2017; Government of Dominica, 2017).

Figure 2
Exposure and vulnerability to climate change.



Source: Prepared by the authors based on ND-GAIN (University of Notre Dame Global Adaptation Iniciative) and Cárdenas (2023). Vulnerability is estimated by adaptive capacity. [8]

Central America have high exposure to climate events and low adaptive capacity (ND-GAIN; IMF, 2021). In addition, institutional weaknesses hinder the implementation of more decisive public policies for adaptation, and the business environment does not facilitate the mobilization of private sector capital compared to developed countries (Cárdenas, 2023). Climate risks also vary within countries depending on local differences in exposure and vulnerability.

The **typology of climate-related disasters** refers to the classification of adverse events that are triggered by meteorological or climatic conditions. These disasters can cause significant human losses in terms of mortality and morbidity.

Disasters can also result in severe economic damage and losses. Damage refers to the destruction of physical infrastructure or natural resources. Meanwhile, losses refer to the impact on the flow of economic activities resulting from the disruption caused by the disaster on the production of goods and services, exports, or fiscal losses.

8. ND-GAIN assesses a country's vulnerability by considering six life-supporting sectors: food, water, health, ecosystem services, human habitat, and infrastructure. Each component is, in turn, measured by six key indicators. One of the dimensions of vulnerability is adaptive capacity, which is defined as the ability of society to adjust in order to reduce potential damages and respond to the negative consequences of climate events.

Given the geographic and climatic diversity of Latin America and the Caribbean, the region is exposed to a wide range of climate-related disasters. Among the most important are the following:

- *Floods:* These occur when there is an excess of water that goes beyond the natural drainage capacity of an area. They can be caused by heavy rains, thaws, floods, or tropical storms. Floods cause damage to infrastructure and loss of life.

- *Storms:* These include tropical storms and hurricanes. These events are characterized by strong winds, heavy rains, and storm surges. They cause damage to public infrastructure and private capital, production losses, coastal flooding, and population displacement.

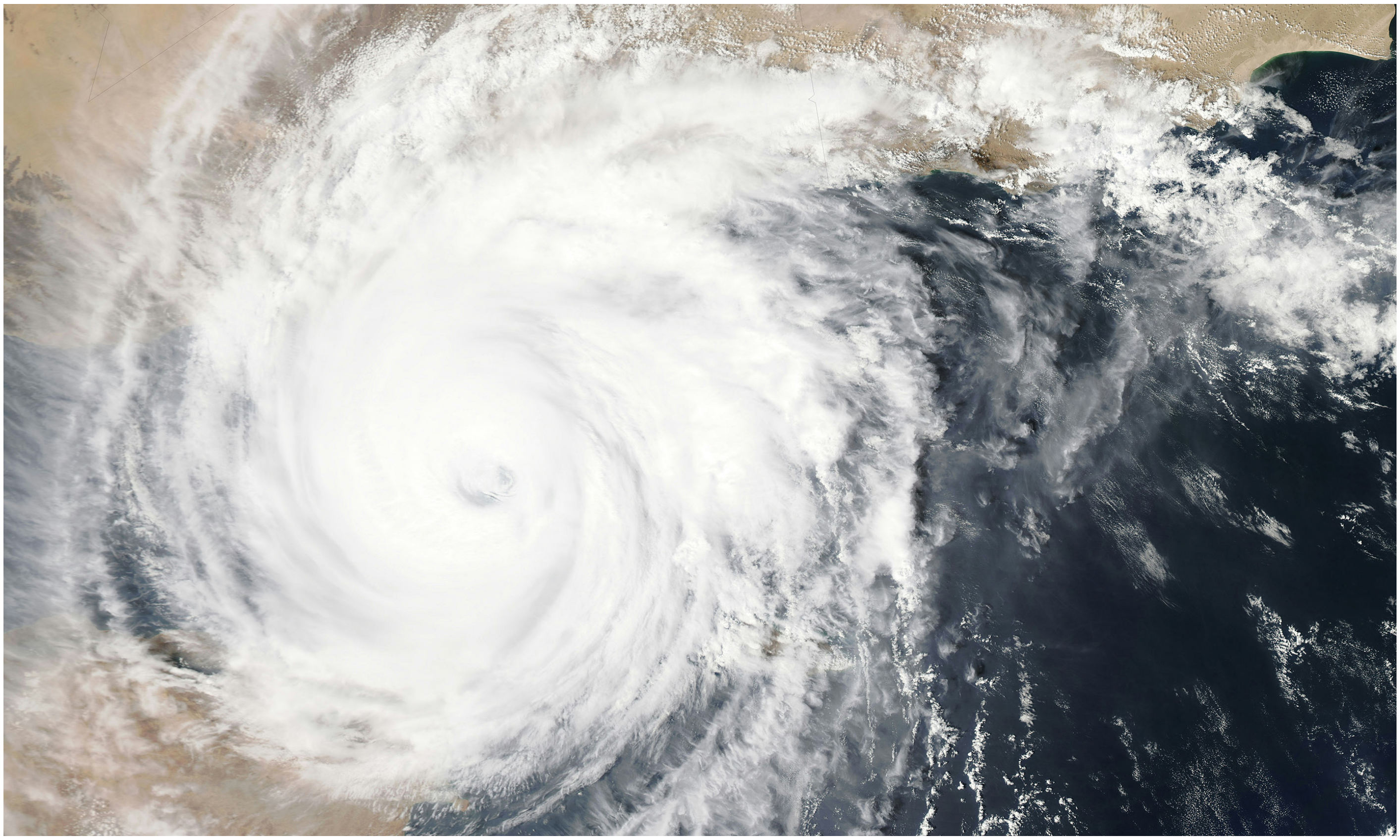
- *Droughts:* These represent a prolonged shortage of rainfall that affects water availability. This can have a devastating impact on agriculture, drinking water supplies, and the economy in general.

- *Extreme Temperatures:* These include heat waves and intense cold. Heat waves can cause people to suffer from heat stress and increase the risk of forest fires. Extreme cold can also have a negative impact on health and infrastructure.

- *Forest Fires:* These are disasters caused by the uncontrolled burning of vegetation. They may be caused by dry conditions and strong winds. Wildfires threaten biodiversity, destroy habitats, and endanger nearby communities.

- *Landslides:* These occur when a mass of earth, rock, and debris flows rapidly downhill. Intense rainfall or seismic events can trigger landslides which pose a risk to infrastructure and human life.

Latin America and the Caribbean have experienced a considerable number of disasters associated with climatic conditions over the last 43 years with a total of 2,225 events registered. This equates to an average of 52 events per year. These disasters have left a significant footprint in terms of damage and losses as well as in terms of the people affected and the economy in general (Table 1).



Climate disasters affect a large fraction of the Latin America and the Caribbean population. An average of 1% of the population was affected each year during the period analyzed. Nevertheless, in the case of Central America and the Caribbean, the impact of these events in terms of population affected was double and triple the regional average respectively (Table 1).

Among the different types of climatic disasters, floods have been the most frequent event and accounted for 49.5% of the total number of cases. Storms have also had a significant impact and accounted for 30.6% of the disasters. On the other hand, droughts, although less frequent, have had a notable impact in terms of their effect on the population since they account for 32.4% of the people affected by climatic events.

Droughts tend to have a broader geographic impact per event and cover almost five times the area affected by an average weather event in the region. In contrast, landslides and storms tend to be more localized and, on average, involve 24.4% and 15.7% of the area affected respectively.

Disasters associated with climate events have caused average annual damages and losses of at least 0.2% of GDP, which represents a considerable economic impact (Table 1). About two-thirds of these damages and losses are related to storms. On average, a storm causes twice as much damage as the "typical event"[9] in the region (Table 2).

It is crucial to highlight the relationship between the intensity of events and their impact in terms of damage, losses, and mortality. Storms, for example, have considerable destructive power and result in significant infrastructure damage. Although fatality rates per event are relatively low overall, the aggregate numbers of deaths are significant due to the recurrence of these events.

It is crucial to highlight the relationship between the intensity of events and their impact in terms of damage, losses, and mortality.

The aggregate number of deaths from disasters in the region between 1980 and 2023 is close to 100,000 people. Fatalities tend to be concentrated in extreme events. For example, almost one third of the quantified deaths are related to the "Tragedy of Vargas" in Venezuela in 1999 (classified as a flood) where nearly 30,000 people lost their lives.

Almost 80% of the deaths during the period were associated with floods and storms that accounted for 46.2% and 33.2% respectively. These climatic conditions have greater impacts on different sub-regions: floods in the Andean region and storms in the Caribbean and Central America.

The incidence and impact of climatic events is uneven throughout the region's vast geography. The Caribbean has experienced a disproportionate burden of disasters and losses that could be related to its greater exposure to storms. Central America has also suffered significant impacts due to its geography and economic and institutional capabilities. In addition, the Andean region has been seriously affected by floods and landslides which could be attributed to its mountainous terrain. The Southern Cone shows a combination of floods and droughts of which the latter are more significant in terms of the impact on people and territory.

9. The "typical event" is an artificial construct that makes it possible to measure the impact of each type of event in each region. This is defined as an event (of any subcategory, in any region) with an average effect on each of the four categories analyzed (damage, people affected, area affected, and deaths). Typical events are also identified by class of disaster and region. This is an aggregation that, by construction, is more homogeneous.

As a result, regional disparities in terms of damage and losses are notable. For example, the Caribbean faces a considerable burden with damages and losses averaging 1.9% of the GDP per year. Central America follows with average annual damages and losses of 0.5% of the GDP.

The remainder of the subregions register lower impacts that range between 0.1% and 0.2% of the annual GDP. The limited economic impact for the rest of the continent is associated with the types of events and the sizes of the economies. For example, the most recent drought in Brazil had severe effects in Rio Grande do Sul with an emergency declared in 80% of the municipalities due to lack of rain, and losses amounting to 3.7% of the state's GDP. However, the impact on Brazil's growth was insignificant since the state accounts for only 6% of the national GDP (CAF, 2023).

Vulnerability to climate events is also manifested in terms of population affected. The Caribbean leads, with an annual average of 3.0% of the population affected. Central America is second, with an average of 2.2% of the population affected annually. In the remainder of the subregions, the impact is lower and ranges between 0.3% and 0.8% of the population.

Storms emerge as the main cause of vulnerability in the Caribbean and account for 97.0% of the damage, 72.5% of the people affected, and 59.2% of the deaths in this region. The average storm in the Caribbean generates damages of 0.3% of the GDP and the region usually faces between 6 and 7 storms per year. The fatality rate is significantly higher in Central America compared to the Caribbean. This could be related to their lower preparedness and capacity to react to these weather events.

The Andean region presents a different pattern with floods being the predominant climatic risk. These events represent 63.6% of all reported disasters and contribute 82.1% of the damage and losses, 67.0% of the people affected, and 82.5% of the deaths.

In contrast, droughts have a limited impact on the Andean region compared to other regions. They generate fewer losses and fewer people affected than in the rest of the subregions with the exception of the Caribbean (in losses) and Mexico (in people affected). Landslides, although geographically localized, can generate considerable damage and losses in the areas affected in the Andean region.

The Southern Cone presents a distribution of disasters similar to that of the Andean region where floods are predominant in terms of frequency, damage and losses, and mortality. However, the preeminence of droughts in terms of the impact on people and territory stands out. Droughts account for 55.3% of the people affected while forest fires contribute an additional 12.4%.

Droughts also have a greater impact in terms of losses as well as in the number of people affected per event compared to other climatic events. The mortality rate in the Southern Cone is lower than in other subregions. This could be attributed to the type of weather conditions that have the main impact on this region as well as its degree of preparedness.

In summary, climate disasters have had a significant impact on the region over the past 43 years. Floods and storms are the main drivers in terms of frequency and damage while droughts have a considerable impact in terms of population affected. The geographical distribution of these events varies by subregion and underscores the importance of being prepared and having responses that are adapted to each context. To the extent that an increase in the frequency of extreme events is anticipated, it is crucial to implement adaptation strategies to manage the risks of these events and protect the region's population, economy, and infrastructure.

Table 1

General statistics on climate disasters in Latin America and the Caribbean, 1980- 2022

Region/Type of disaster	Number of events	Damages and losses, adjusted		Affected		Deaths		Area Affected	
		Total (´000 USD)	% GDP/year	Total	% Population/year	Total	% Affected	Total (Km2)	% Territory/year
Caribbean	**446**	**166,680,000**	**1.82%**	**50,772,809**	**3.04%**	**12,658**	**0.02%**	**3,153,703**	**33.91%**
Drought	19	447,069	0.00%	6,721,545	0.40%	0	0.00%	106,471	1.14%
Extreme Temperatures	0	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Flood	146	1,935,298	0.02%	7,396,612	0.44%	5,065	0.07%	1,334,014	14.34%
Landslides	4	0	0.00%	2,435	0.00%	102	4.19%	336	0.00%
Storms	274	164,297,633	1.80%	36,652,217	2.19%	7,491	0.02%	1,696,773	18.24%
Forest Fires	3	0	0.00%	0	0.00%	0	0.00%	16,110	0.17%
Central America	**348**	**25,322,180**	**0.47%**	**36,854,189**	**2.21%**	**24,978**	**0.07%**	**7,580,533**	**36.29%**
Drought	37	1,199,754	0.02%	11,750,616	0.70%	41	0.00%	833,319	3.99%
Extreme Temperatures	6	5,040	0.00%	12,634	0.00%	7	0.06%	184,290	0.88%
Flood	167	3,063,928	0.06%	8,036,560	0.48%	1,904	0.02%	3,874,397	18.55%
Landslides	16	677,230	0.01%	61,585	0.00%	800	1.30%	110,975	0.53%
Storms	113	20,204,320	0.38%	16,971,655	1.02%	22,226	0.13%	2,193,603	10.50%
Forest Fires	9	171,908	0.00%	21,139	0.00%	0	0.00%	383,949	1.84%
Mexico	**201**	**58,392,662**	**0.17%**	**14,881,525**	**0.34%**	**5,396**	**0.04%**	**40,856,246**	**52.00%**
Drought	6	2,948,401	0.01%	2,565,000	0.06%	0	0.00%	4,583,459	5.83%
Extreme Temperatures	15	821,981	0.00%	136,000	0.00%	1,098	0.81%	8,204,167	10.44%
Flood	63	6,527,763	0.02%	4,568,218	0.10%	1,927	0.04%	8,303,172	10.57%
Landslides	9	0	0.00%	320	0.00%	214	66.88%	271,046	0.34%
Storms	104	47,883,739	0.14%	7,611,987	0.17%	2,107	0.03%	18,624,859	23.70%
Forest Fires	4	210,778	0.00%	0	0.00%	50	0.00%	869,543	1.11%
Andean Region	**434**	**28,363,483**	**0.14%**	**41,950,598**	**0.84%**	**44,833**	**0.11%**	**79,880,839**	**42.55%**
Drought	21	4,102,082	0.02%	8,203,909	0.16%	0	0.00%	7,502,635	4.00%
Extreme Temperatures	16	116,066	0.00%	5,435,392	0.11%	2,057	0.04%	5,409,244	2.88%
Flood	276	18,708,712	0.09%	25,662,522	0.51%	36,424	0.14%	55,254,491	29.44%
Landslides	86	5,132,995	0.03%	508,314	0.01%	5,488	1.08%	4,177,873	2.23%
Storms	20	303,628	0.00%	1,145,916	0.02%	809	0.07%	2,848,106	1.52%
Forest Fires	15	0	0.00%	294,545	0.01%	55	0.02%	4,688,489	2.50%
Expanded Southern Cone	**454**	**82,287,013**	**0.11%**	**114,608,403**	**1.09%**	**8,230**	**0.01%**	**118,981,360**	**22.71%**
Drought	34	28,898,913	0.04%	66,716,237	0.63%	44	0.00%	19,754,294	3.77%
Extreme Temperatures	27	2,230,299	0.00%	91,525	0.00%	240	0.26%	10,334,487	1.97%
Flood	283	46,196,917	0.06%	36,144,436	0.34%	6,307	0.02%	67,585,389	12.90%
Landslides	25	376,513	0.00%	356,632	0.00%	1,035	0.29%	2,070,319	0.40%
Storms	56	1,363,630	0.00%	831,191	0.01%	477	0.06%	9,046,202	1.73%
Forest Fires	29	3,220,741	0.00%	10,468,382	0.10%	127	0.00%	10,190,669	1.95%
General Total	**2225**	**361,045,338**	**0.26%**	**259,067,524**	**1.11%**	**96,095**	**0.04%**	**250,452,681**	**33.76%**
Drought	154	37,596,219	0.03%	95,957,307	0.41%	85	0.00%	32,780,178	4.42%
Extreme Temperatures	64	3,173,386	0.00%	5,675,551	0.02%	3,402	0.06%	24,132,188	3.25%
Flood	1102	76,432,618	0.05%	81,808,348	0.35%	51,627	0.06%	136,351,463	18.38%
Landslides	156	6,186,738	0.00%	929,286	0.00%	7,639	0.82%	6,630,549	0.89%
Storms	680	234,052,950	0.17%	63,212,966	0.27%	33,110	0.05%	34,409,543	4.64%
Forest Fires	69	3,603,427	0.00%	10,784,066	0.05%	232	0.00%	16,148,760	2.18%

Source: EM-DAT, The international disaster database

1/ Refers to the value, adjusted for inflation, of all the damages and economic losses that are directly or indirectly related to the disaster
2/ Refers to the number of people who required immediate assistance during the emergency.
3/ Refers to deceased and missing people.
4/ The “ Extended Southern Cone” includes Argentina, Brazil, Chile, Guyana, Paraguay, Suriname, and Uruguay. The inclusion of Guyana and Suriname is for completeness and does not significantly affect the results.

Table 2

Impact of typical climate events in Latin America and the Caribbean, 1980-2022

Region/Type of disaster	Damages 1/		People Affected 2/		Deaths 3/		Area Affected		Mortality rate	Affected rate	Damage rate / GDP	Area affected/Total
		%e. typical region 5/		%e. typical region 5/		%e. typical region 5/		%e. typical region 5/	(per 100.000 inhabitants)	(per 100.000 inhabitants)		
Caribbean	**367,137**	**231.24%**	**111,834**	**98.2%**	**28**	**66.0%**	**6,946**	**6.3%**	**0.07**	**287.61**	**0.17%**	**2.99%**
Drought	22,353	14.1%	336,077	**295.0%**	0	0.0%	5,324	4.8%	0.00	864.29	0.01%	2.29%
Extreme Temperatures	0	0.0%	0	**0.0%**	0	0.0%	0	0.0%	0.00	0.00	0.00%	0.00%
Flood	13,076	8.2%	49,977	43.9%	34	81.0%	9,014	8.2%	0.09	128.53	0.01%	3.88%
Landslides	0	0.0%	609	0.5%	26	60.3%	84	0.1%	0.07	1.57	0.00%	0.04%
Storms	590,999	**372.2%**	131,843	115.7%	27	63.8%	6,103	5.5%	0.07	339.06	0.28%	2.62%
Forest Fires	0	0.0%	0	0.0%	0	0.0%	4,028	3.7%	0.00	0.00	0.00%	1.73%
Central America	**72,143**	**45.4%**	**104,998**	**92.2%**	**71**	**168.4%**	**21,597**	**19.6%**	**0.18**	**270.76**	**0.06%**	**4.14%**
Drought	31,572	19.9%	309,227	**271.4%**	1	2.6%	21,929	19.9%	0.00	797.42	0.03%	4.20%
Extreme Temperatures	840	0.5%	2,106	1.8%	1	2.8%	30,715	27.9%	0.00	5.43	0.00%	5.88%
Flood	18,130	11.4%	47,554	41.7%	11	26.7%	22,925	20.8%	0.03	122.63	0.01%	4.39%
Landslides	42,327	26.7%	3,849	3.4%	50	118.3%	6,936	6.3%	0.13	9.93	0.03%	1.33%
Storms	178,799	**112.6%**	150,192	131.8%	197	**465.4%**	19,412	**17.6%**	0.51	387.31	0.14%	3.72%
Forest Fires	19,101	12.0%	2,349	2.1%	0	0.0%	42,661	38.7%	0.00	6.06	0.02%	8.17%
Mexico	**283,460**	**178.5%**	**72,240**	**63.4%**	**26**	**62.0%**	**198,331**	**180.1%**	**0.03**	**70.44**	**0.04%**	**10.10%**
Drought	491,400	309.5%	427,500	375.2%	0	0.0%	763,910	693.6%	0.00	416.87	0.06%	38.89%
Extreme Temperatures	54,799	34.5%	9,067	8.0%	73	173.2%	546,944	496.6%	0.07	8.84	0.01%	27.84%
Flood	101,996	64.2%	71,378	62.7%	30	71.3%	129,737	117.8%	0.03	69.60	0.01%	6.60%
Landslides	0	0.0%	32	0.0%	21	50.6%	27,105	24.6%	0.02	0.03	0.00%	1.38%
Storms	447,512	281.9%	71,140	62.4%	20	**46.6%**	174,064	158.0%	0.02	69.37	0.06%	8.86%
Forest Fires	52,695	33.2%	0	0.0%	13	29.6%	217,386	197.4%	0.01	0.00	0.01%	11.07%
Andean Region	**63,453**	**40.0%**	**93,849**	**82.4%**	**100**	**237.3%**	**178,704**	**162.3%**	**0.09**	**80.89**	**0.01%**	**3.81%**
Drought	170,920	**107.7%**	341,830	**300.0%**	0	0.0%	312,610	283.8%	0.00	294.62	0.04%	6.66%
Extreme Temperatures	6,827	4.3%	319,729	280.6%	121	286.3%	318,191	288.9%	0.10	275.57	0.00%	6.78%
Flood	66,817	42.1%	91,652	80.4%	130	**307.8%**	197,337	**179.2%**	0.11	78.99	0.01%	4.21%
Landslides	57,033	35.9%	5,648	5.0%	61	144.3%	46,421	42.1%	0.05	4.87	0.01%	0.99%
Storms	14,458	9.1%	54,567	47.9%	39	91.2%	135,624	123.1%	0.03	47.03	0.00%	2.89%
Forest Fires	0	0.0%	19,636	17.2%	4	8.7%	312,566	283.8%	0.00	16.92	0.00%	6.66%
Expanded Southern Cone 4	**174,707**	**110.0%**	**243,330**	**213.6%**	**17**	**41.3%**	**252,614**	**229.4%**	**0.01**	**99.32**	**0.01%**	**1.93%**
Drought	802,748	**505.6%**	1,853,229	**1626.7%**	1	2.9%	548,730	498.2%	0.00	756.42	0.05%	4.19%
Extreme Temperatures	82,604	52.0%	3,390	3.0%	9	21.0%	382,759	347.5%	0.00	1.38	0.00%	2.92%
Flood	157,669	**99.3%**	123,360	108.3%	22	50.9%	230,667	209.4%	0.01	50.35	0.01%	1.76%
Landslides	13,945	8.8%	13,209	11.6%	38	90.7%	76,678	69.6%	0.02	5.39	0.00%	0.59%
Storms	23,112	14.6%	14,088	12.4%	8	19.1%	153,325	139.2%	0.00	5.75	0.00%	1.17%
Forest Fires	111,060	69.9%	360,979	316.9%	4	10.4%	351,402	319.1%	0.00	147.34	0.01%	2.68%
General Total	**158,771**	**100.0%**	**113,926**	**100.0%**	**42**	**100.0%**	**110,138**	**100.0%**	**0.01**	**21.05**	**0.01%**	**0.54%**
Drought	232,075	146.2%	592,329	519.9%	1	1.2%	202,347	183.7%	0.00	109.44	0.01%	0.99%
Extreme Temperatures	48,821	30.7%	87,316	76.6%	52	123.9%	371,264	337.1%	0.01	16.13	0.00%	1.81%
Flood	68,061	42.9%	72,848	63.9%	46	108.8%	121,417	110.2%	0.01	13.46	0.00%	0.59%
Landslides	37,955	23.9%	5,701	5.0%	47	110.9%	40,678	36.9%	0.01	1.05	0.00%	0.20%
Storms	338,716	213.3%	91,480	80.3%	48	113.4%	49,797	45.2%	0.01	16.90	0.02%	0.24%
Forest Fires	51,478	32.4%	154,058	135.2%	3	7.8%	230,697	209.5%	0.00	28.46	0.00%	1.12%

Source: EM-DAT, The international disaster database

1/ Refers to the value, adjusted for inflation, of all the damages and economic losses that are directly or indirectly related to the disaster
2/ Refers to the number of people who required immediate assistance during the emergency.
3/ Refers to deceased and missing people.
4/ The " Extended Southern Cone" includes Argentina, Brazil, Chile, Guyana, Paraguay, Suriname, and Uruguay. The inclusion of Guyana and Suriname is for completeness and does not significantly affect the results. 5/ Refers to the magnitude of the specific category as a percentage of the magnitude of the typical event in the region (normalization).

3 The economic impact of extreme weather events under different adaptation policy scenarios.

The macroeconomic effects associated with extreme weather events in four of the countries in the region with the highest exposure to both hydro-meteorological threats and climate change are quantitatively assessed in this section: Honduras, Dominican Republic, Barbados, and Paraguay (CAF, 2014; IMF, 2022). These exercises consider different scenarios for implementing public policies prior to the occurrence of the simulated events such as investment in resilient infrastructure and/or the creation of a contingency fund while analyzing in detail the impact of these policies on the dynamics of the GDP and public debt.

To this end, the dynamic general equilibrium model DIGNAD[10] (*Debt-Investment-Growth and Natural Disasters*), duly calibrated to these countries, is used to analyze the response of the economy to a given climate shock.

10. This model and the associated toolkit, developed by the IMF, are based on the work of Buffie et al. (2012) and Marto et al. (2018). In the model, the economy is composed of three agents: Households, businesses, and government which make decisions on consumption, investment, labor supply and demand, production, and fiscal and adjustment policy. The interrelation of these agents and their decisions determine, jointly and simultaneously, the performance of macroeconomic variables of interest such as GDP, public debt, etc. For further details, see Aligishiev et al. (2023).

The model makes it possible to quantify the macroeconomic and fiscal effects of a natural disaster that causes damage to public infrastructure and private capital as well as losses in total factor productivity.[11] In addition, it makes it possible to quantify these impacts under different adaptation policy scenarios.

In this respect, an important feature of the model is that it supports the simultaneous presence of two types of public infrastructure (or public capital): resilient infrastructure and standard infrastructure. Resilient, or adaptive, infrastructure mitigates damage from natural disasters: a larger stock reduces the damage to the total capital stock (private and public) which depends on a mitigation parameter on capital.[12] While standard infrastructure, in turn, has no mitigating effect, it is usually less costly than resilient infrastructure, and this is also captured by the model. Likewise, standard and resilient infrastructure may have different depreciation and return rates (marginal productivities). In particular, if resilient infrastructure has a higher return and a lower depreciation rate than traditional infrastructure, investing in the former increases the productivity of both private capital and employment regardless of the occurrence of an extreme weather event.

Standard and resilient infrastructure may have different depreciation and return rates (marginal productivities).

Despite being highly detailed in multiple dimensions, the model also makes significant simplifications that must be considered. The main one is that the magnitude of the disaster-related damage and losses are exogenous and independent of the initial stock of resilient infrastructure. Therefore, given the structure of the model, a scenario with non-zero initial resilient capital and a climate event with certain damages and losses (impacts) is equivalent to one with zero resilient capital and an event with a lower impact. Thus, the results are best interpreted as economic impacts prevented by investments in resilient infrastructure.

Secondly, the economic impacts prevented in the model are a fixed proportion that depends solely on the level of resilient infrastructure. In other words, its mitigation potential is independent of the magnitude of the damages and losses considered. From an empirical perspective, however, it is possible to argue that the percentage of mitigated impacts could be lower to the extent that events become more extreme. Therefore, this makes it difficult to make a direct comparison between two scenarios with the same stock of resilient capital but which differ considerably in the level of damage and losses.

11. Ecological damages as well as potential human losses are not captured by the model.

12. A standard type road, for example, consists of asphalt and concrete with no special considerations. In contrast, a resilient road is made of impervious materials that facilitate drainage, can be elevated in flood-prone areas, or have improved drainage systems that are functional in the event of flooding.

Climate shocks. The climatic events were chosen for their historical or potential relevance (as a result of climate change) for each country: a hurricane in the case of Honduras, Dominican Republic, and Barbados, and a drought in the case of Paraguay. The year of occurrence of the climatic event is determined by using a frequency that is 20% higher than the historical frequency of this type of event in each country or region, starting in 2023, the initial year of the exercise. The magnitude of damage and losses, in turn, reflect both the average damage per country/region plus one standard deviation and extreme events that occur in a given country. These assumptions are motivated by the scientific consensus on the effects of climate change: the occurrence of more frequent extreme events.[13] For simplicity, the initial stock of resilient infrastructure in the four countries is assumed to be zero.[14]

At this point, it is important to highlight the qualitative differences between hurricanes and droughts. Hurricanes and associated floods generate both economic losses (production and productivity) and damage to private and public capital. Resilient infrastructure includes, in this case, the reinforcement of buildings, bridges, and roads, improvement in storm water drainage, urban planning, etc. In the model, investment in this type of infrastructure reduces the damage to capital resulting from the weather event and increases the productivity of private capital and employment.

In contrast, in the case of droughts, damages and losses are concentrated almost exclusively in production losses. For the purposes of this exercise, capital damage from droughts is assumed to be zero. Drought resilient or adaptive infrastructure includes the construction of water storage reservoirs, rainwater harvesting systems, wastewater treatment and reuse, and the implementation of drip or subsurface irrigation systems. Also, due to the structure of the model, it was necessary to add a parameter to capture the mitigating effect of drought adaptation infrastructure on total factor productivity.[15] Note also that, just as in the case of hurricanes, investment in adaptive infrastructure increases the productivity of private capital and employment.[16]

13. See Climate Change 2023: Synthesis Report. IPCC, Geneva, Switzerland, pp. 1-34.

14. Although this is not the case for the Dominican Republic and Honduras, for countries that have made climate change adaptation investments, the structure of the model makes it possible to assume zero capital as long as the damages and losses associated with the event are reduced.

15. In the current version of the DIGNAD model, the mitigating effect of resilient infrastructure is channeled solely through lower damages in total capital stock. As a consequence, if capital damages are nil, as assumed in the case of a drought, the mitigating effects would be insignificant.

16. For example, the implementation of drip irrigation systems, which are part of private capital, increases land productivity regardless of the occurrence of a drought.

Thus, the exercise considers three scenarios per country:

- In the first, no change is made, so the government invests in only standard infrastructure based on the historical pattern.
- In the second scenario, each country invests a certain percentage of GDP annually in resilient infrastructure, which is financed with concessional and/or commercial debt, starting in 2023. The level of investment in resilient infrastructure chosen in each country ensures that, in the medium term, the trajectory of the public debt-to-GDP ratio is not explosive. These levels are also within the range of adaptation investment discussed in the introduction (between 0.15% and 0.5% of GDP per year).
  In the cases of Honduras, Barbados, and Paraguay, they are assumed to be financed entirely with concessional debt due to the limited access to international markets of the first two and the low tax burden of the last one.[17] The Dominican Republic, in turn, which has a lower risk premium, finances resilient infrastructure investment with 50% commercial debt and 50% concessional debt.[18]
- Finally, in the third scenario, in addition to the same investment in resilient infrastructure as in the second scenario, the creation of a contingency fund where the same amount that is invested in resilient infrastructure is saved annually is assumed. In this case, the financing plan is the same as in the second scenario.

The level of investment in resilient infrastructure chosen in each country ensures that, in the medium term, the trajectory of the public debt-to-GDP ratio is not explosive.

Calibration. The depreciation rates for traditional (7.0%) and resilient (3.5%) infrastructure as well as that for private capital (5.0%) are taken from Marto et al (2018). The 50% rate of return for resilient infrastructure is taken from this same study while the rate of return for standard infrastructure is set at 35% and is within the range estimated for Latin American and Caribbean countries in Canning and Bennathan (2000). The additional cost of resilient compared to standard infrastructure (20% for all cases), in turn, is in line with Cantelmo et al. (2019) and Fernandez-Corugedo et al. (2023) for storms and hurricanes as well as with estimates in the UK National Infrastructure Assessment (2018) for the case of droughts.

17. In the last decade, tax revenue in Paraguay was around 10% of the GDP which includes VAT and ISR.

18. Two alternative exercises where the investment in resilient infrastructure and the creation of the contingency fund are financed entirely with commercial debt are shown in the Appendix section.

Table 3
Quantitative exercise assumptions

	Honduras	Dominican Republic	Barbados	Paraguay
Disaster	Hurricane	Hurricane	Hurricane	Drought
Year	t + 6	t + 6	t + 8	t + 5
Damages and Losses (%GDP)	**10.0%**	**6.0%**	**14.0%**	**5.0%**
Losses	3.3%	2.2%	5.2%	5.0%
Damages	6.7%	3.8%	8.8%	0.0%
Public (Infrastructure) Capital	4.9%	1.9%	4.4%	0.0%
Private Capital	1.8%	1.9%	4.4%	0.0%
Depreciation rates				
Standard Infrastructure	3.5%	3.5%	3.5%	3.5%
Resilient Infrastructure	7.0%	7.0%	7.0%	7.0%
Private Capital	5.0%	5.0%	5.0%	5.0%
Infr. mitigation. Resilient (stock = 5% of initial GDP)	**50%**	**50%**	**50%**	**50%**
Return on Infr. Standard	35%	35%	35%	35%
Return on Infr. Resilient	**50%**	**50%**	**50%**	**50%**
Additional cost of infrastructure Resilient vs. Standard	20%	20%	20%	20%
Scenario 2 (% annual GDP)				
Resilient Infrastructure Investment	**0.5%**	**0.4%**	**0.5%**	**0.5%**
Concessional Debt	0.5%	0.2%	0.5%	0.5%
Commercial Debt	-	0.2%	-	-
Grants	-	-	-	-
Scenario 3 (% annual GDP)				
Resilient Infrastructure Investment	**0.5%**	**0.4%**	**0.5%**	**0.5%**
Emergency fund	**0.5%**	**0.4%**	**0.5%**	**0.5%**
Concessional Debt	1.0%	0.4%	1.0%	1.0%
Commercial Debt	-	0.4%	-	-
Grants	-	0.5%	-	-
Public Debt (% GDP)	48%	57%	118%	41%
EMBI/Spread (August 2023)	**440**	**306**	**500**	**205**
Tax Revenue (% GDP)	19.1%	13.2%	27.1%	10.0%

Regarding the mitigation potential of resilient or adaptive infrastructure, a study by the World Economic Forum (2014) finds that such infrastructure can prevent up to 65% of damages and losses in developed countries while mitigation reaches 50% for drought in the case of India. The exercise assumes that a resilient infrastructure stock equivalent to 5% of initial GDP can prevent 50% of total damages (private and public) in the case of hurricanes and 50% of losses in the case of droughts.19 Details of all assumptions are presented in Table 3.

19. The default value in the DIGNAD model toolkit is such that, based on Marto et al, an infrastructure stock of 5% of the GDP prevents 33% of the damages. (2018). That document, however, is a study of the impact of Cyclone Pam in Vanuatu in 2015 which left damage and losses in excess of 60% of the GDP. The choice of a higher percentage of damages (and losses) averted in this note reflects the fact that the economic impact of the events considered are of a much smaller magnitude than those seen in Vanuatu.

Results. Figure 3 shows the results of these exercises for GDP growth and the ratio of public debt to GDP with respect to its level in 2022. The main messages are listed below:

1. In all cases, investment in resilient or adaptive infrastructure raises GDP in the years prior to any disaster due to an increase in private investment and employment as a result of an increase in the productivity of these factors. This investment also mitigates the negative effects of the extreme weather events on GDP. Likewise, the mitigating effect on growth depends to a large extent on the size of the investment. For example, with 7 years of investing 0.5% of pre-hurricane GDP, Barbados experiences a 45% lower reduction in its GDP than in the absence of resilient investment: 3 percentage points (pp) vs 5.5 pp, respectively.

Investment in resilient infrastructure improves the trajectory of public debt to GDP in the medium and long term.

2. Investment in resilient infrastructure (scenario 2) improves the trajectory of public debt to GDP in the medium and long term. In the absence of this investment, the debt-to-GDP ratio would permanently increase (scenario 1). This is mainly due to the mitigating effects of resilient infrastructure, which not only results in a smaller drop in GDP, but also a faster recovery as well as lower reconstruction costs.

3. Resilient investment, however, also generates a tension between managing public debt in the short and the medium term since that investment means that the debt-to-GDP ratio will temporarily rise before and in the aftermath of the climate shock. This increase could discourage governments from implementing such investments and prioritize other types of expenditures (social, standard infrastructure) while preserving debt sustainability. For example, in Honduras, investing in resilience would mean an increase of almost 2 pp in the public debt-to-GDP ratio prior to the hurricane and up to an additional 6 pp 5 years after the event from an initial level of 48% of the GDP. Although the increase in the public debt-to-GDP ratio in the 5 years after the hurricane, in turn, is only 3.6 pp in the Dominican Republic, this is sufficient for the country's debt to reach the threshold of 60% of the GDP.[20]

20. Another factor to consider is the possibility that a subsequent administration could gain political advantage by reducing damages and losses from such investments.

4. Moreover, the exercises for the Dominican Republic and Paraguay show that, when investing in resilience (scenario 2), the debt-to-GDP ratio is higher than the one in scenario 1 for 15 and 20 years, respectively, after the event. In the case of the Dominican Republic, this occurs mainly because 50% of this investment is financed with commercial debt at a higher market rate. In Paraguay, in turn, although fully concessional financing is assumed, the tax burden is low and makes debt reduction difficult in the absence of significant fiscal adjustment. Therefore, in both countries, the incentives to make resilient investments under scenario 2 could be low.

5. Establishing a contingency fund together with investment in resilient infrastructure (scenario 3) has marginal benefits for the pace of recovery of GDP growth but improves medium-term debt dynamics compared to only making the resilient investment (scenario 2). However, this combination further worsens the debt-to-GDP ratio before the weather event: in Honduras, this ratio rises 4 pp, in the Dominican Republic 4 pp, in Barbados 5 pp, and in Paraguay close to 4 pp. In addition, in the case of the Dominican Republic and Paraguay, the debt in scenario 3 remains higher than that in scenario 1 for up to 12 years after the climate event. This may not represent a sufficiently attractive improvement over the second scenario.

6. Finally, all the models considered assume partial or total concessional financing. In the absence of this type of financing, the debt trajectory would only improve in the long run. Also, financing resilient infrastructure investment with non-concessional debt could worsen debt dynamics with respect to the case without resilient investment. Of the four countries, only Barbados shows better debt dynamics when it makes resilient investments than when it does not.[21] The worsening of the debt trend is due, on one hand, to the fact that the mitigating effects of resilient infrastructure are not large enough to offset the increase in the cost of debt and, on the other, to the fact that this increase in debt service limits the government's ability to cope with the disaster and thus slows recovery down.

21. See the third column of Figure 3. See Appendices section for more details.

Figure 3
Main results of the quantitative exercises

Note: The first two columns show GDP and public debt/GDP for the exercises described in Section 3 (scenarios 1-3). The third column shows the public debt/GDP of two alternative exercises where the investment in resilient infrastructure and the creation of the contingency fund are financed entirely with commercial debt.

4 Concluding remarks: Policy Recommendations

The previous analysis suggests that investing in resilient infrastructure is crucial for easing the impact of extreme climate events on GDP and improving the trajectory of public debt in the medium and long term. While these investments and the creation of emergency funds may increase public debt in the short term, without these measures, countries would face a vicious cycle of growing debt and reduced ability to invest in resilient infrastructure that would exacerbate the negative impact on production. In this regard, the climate change adaptation and inclusion agendas converge on this point given that the lower income sectors, which have limited capacity to manage risks and have greater vulnerability in housing, are those who face greater climate risk.

The exercise also shows the fundamental role played by concessionary debt. This type of financing not only makes it possible to undertake the necessary investments in resilient infrastructure, but also prevents a severe deterioration in debt dynamics in the short and medium term that is similar to or worse than the scenario without resilient investments. Multilateral banking and bilateral and global climate cooperation are therefore positioned as essential allies of the countries in the region and can ensure that they are able to adapt to climate change through appropriate investments. In addition to concessional loans, multilateral organizations can mobilize capital to the region and offer contingent financial products that do not result in higher debt levels: disaster contingent funds, disaster contingent repayment programs for regular loans, etc.

Concessional financing addresses two fundamental problems. One has to do with the possible presence of financial frictions in the case of highly indebted countries. In these countries, debt levels could interact with interest rates to generate unstable dynamics that would make it difficult to finance the additional cost of resilient infrastructure unless the cost of financing the additional debt is lower. There is, in addition, a political economy problem associated with the relevant planning horizons. The returns on resilient infrastructure depend on the materialization of natural events which, by their nature, are not predictable. Therefore, there is a mismatch between the costs, which are paid in the short term, and the eventual returns that would materialize in the medium or long term. This could result in suboptimal investment levels for this type of infrastructure. To address this shortcoming, it may be useful to establish special financing conditions that include extended payment terms and repayment grace periods.

Differentiation between Climate change adaptation (CCA) and disaster risk reduction (DRR) has been mainly based on their approach to hazards.

Beyond investment in resilient infrastructure, governments in the region need to accelerate the climate risk reduction agenda as well as encourage progressive adaptation to impacts that cannot be avoided or eliminated. Actions in this regard should target the different determiners of vulnerability that are closely linked in Latin America and the Caribbean to growing inequality and exclusion, the increase in the number of people falling into poverty each year, chaotic urbanization patterns, indiscriminate exploitation of natural resources, and environmental deterioration. In short, to overcome an increasing concentration of risk, capital investments with a risk reduction and resilience approach are needed in multiple areas such as energy, agriculture, transportation, water and sanitation, irrigation, and biodiversity.

Therefore, analysis and public and private investment decisions should be catalysts for reducing risks and increasing resilience, thus preventing further losses and making progress towards achieving sustainable development goals. The scale of these investments varies depending on the scope of the objective and the technologies adopted, but the central message is that investing in sectoral, territorial, social, and environmental resilience to rapidly changing climate conditions is not only a good investment but also a good development policy.

This requires governments and society in general to adopt an integrated approach to disaster risk reduction and climate change adaptation. The increasing recurrence and intensity of disasters and the multidimensional nature of their impact on the region have heightened the need to move, not without difficulty, towards a comprehensive approach that not only addresses disasters, but also emphasizes the role of an approach that is integrated with the climate adaptation agenda. Differentiation between Climate change adaptation (CCA) and disaster risk reduction (DRR) has been mainly based on their approach to hazards. While adaptation refers to climate-related hazards with medium- and long-term scenarios and projections of the average trends of climate variables (mainly temperature and precipitation), DRR deals with all types of hazards that may generate risk conditions, and which, if they materialize, may generate disaster situations. In contrast to concepts such as vulnerability, both frameworks converge in understanding it as the preconditions of an element or system exposed to a hazard that make it more susceptible to being affected by it. Therefore, beyond this difference in threats, both conceptual frameworks have many points in common.

A common framework that integrates disaster risk reduction (DRR) and climate change adaptation (CCA) is of utmost importance in view of the growing environmental challenges. Such a framework serves as a cohesive strategy that recognizes the interaction between climate change and the increasing frequency and severity of disasters. By aligning DRR and CCA efforts, governments, organizations, and communities can optimize resources, improve resilience, and promote sustainable development. This synergy makes more effective adaptation and risk reduction strategies possible and ensures that communities are better prepared to withstand climate-related hazards and recover quickly when disasters occur.

The characteristics of a common framework between DRR and CCA generally include a holistic and forward-looking approach that assesses current vulnerabilities, anticipates future climate impacts, and integrates these considerations into policy, planning, and implementation. It emphasizes the importance of community commitment and participation since local knowledge is invaluable in the development of context-specific strategies. In addition, the framework incorporates scientific data and early warning systems to monitor climate trends and disaster risks that will enable timely response and adaptive management. It also promotes ecosystem-based approaches in recognition of the fundamental role of natural systems in reducing vulnerability and increasing resilience.

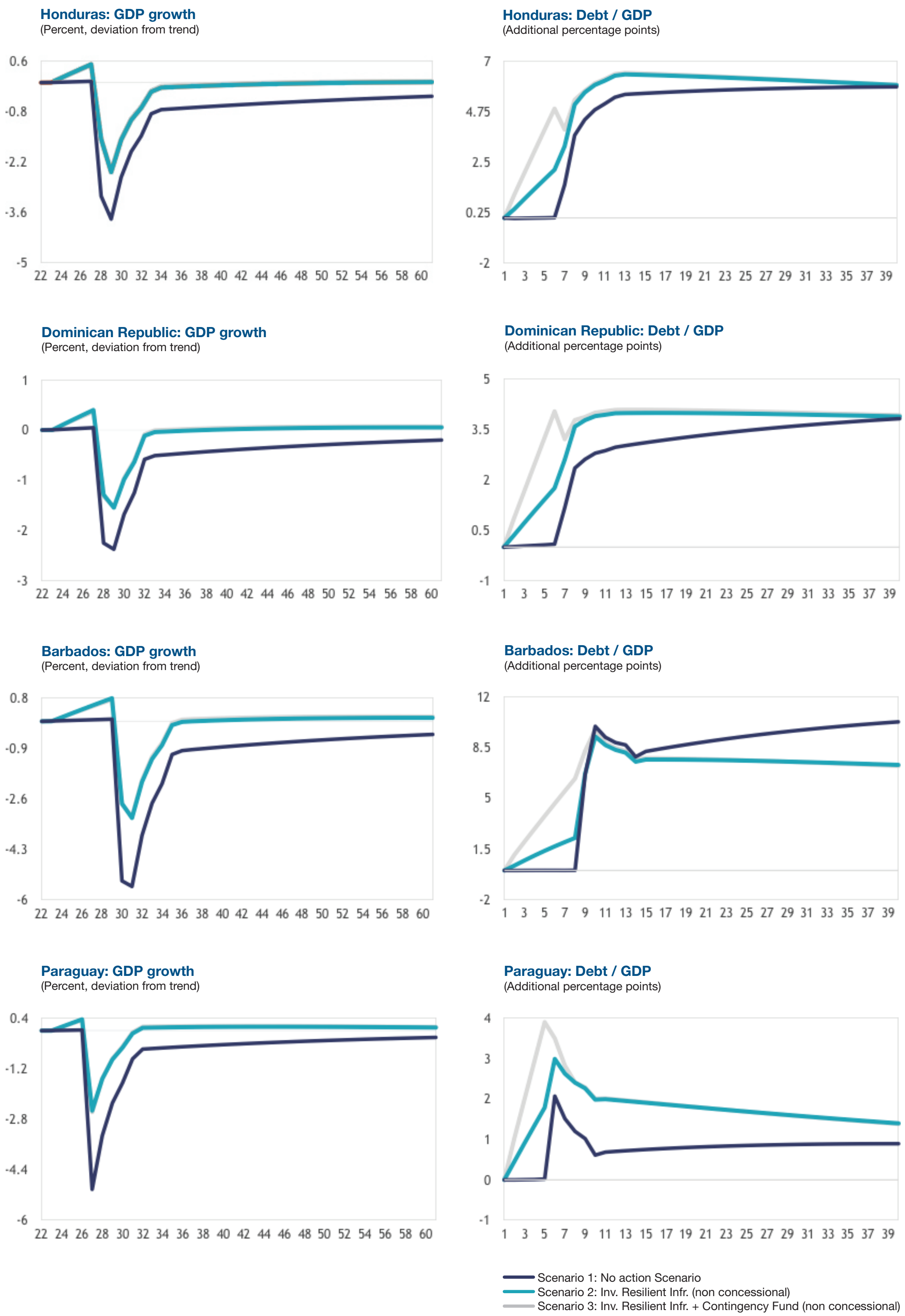
Overall, a common framework linking DRR and CCA is a basic tool for building adaptive and resilient societies in response to a changing climate and increasing disaster risks.

Finally, any DRR and CCA initiative should be framed within a broad development strategy that takes complementary factors and tensions with other development objectives facing the region into consideration. This is particularly relevant in countries with limited fiscal flexibility and capabilities. This is in order to achieve an appropriate and efficient allocation of resources for multiple objectives and to prevent concessional financing for adaptation from competing with the financing of other priority objectives for the development of societies.

5 Appendices

Figure A.1 shows the results of the quantitative exercises based on the assumption that all investment in resilient infrastructure and the creation of the emergency fund are financed with non-concessional loans. All the other assumptions for each country remain the same.

Figure A.1
Results of climate shocks without concessional debt



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