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EDITORIAL NOTES

Disasters and Climate Change in Latin America and the Caribbean: An Introduction to the Special Issue

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Abstract

This introduction seeks to provide context for the papers included in this special issue by drawing on the broader literature. Salient development challenges for Latin America and the Caribbean, which can be aggravated by climate change, are low economic growth, high poverty and inequality, and fiscal vulnerabilities. This paper summarizes some of the evidence on the economic implications of climate change with an emphasis on the evidence pertaining to Latin America and the Caribbean; and how the research papers included in this special issue provide answers for some of the relevant and remaining questions about this topic.

Keywords Climate changes · disasters · economic impacts · development challenges

JEL Codes O13 · Q54 · Q56 · O54

Global temperatures have been steadily trending upward since the early twentieth century. Panel A of Fig. 1 shows that the global temperature anomaly, or the difference between the annual mean temperature and the mean temperature over 1901–2000, has steadily climbed. As is observed globally, the temperature in Latin America and the Caribbean has also steadily trended upward, with temperatures in South America increasing even more rapidly than in the Caribbean (see Panel B of Fig. 1).

Global temperatures have increased faster since the 1970s (Gulev et al. 2021). Panel A of Fig. 2 shows that the average global temperature anomaly has increased in each decade since the 1950s. Panel B of Fig. 2 shows a similar acceleration of rising temperature in South America and the Caribbean. More recently, seven years between 2015 and 2022 have been the warmest in recorded history. In particular, the years 2016 and 2020 stand out as the hottest years to date (NOAA National Centers for Environmental information n.d.).

Despite some progress in reducing GHG emissions, the climate will continue to change as long as we keep emitting more GHGs to the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) predicts that climatic changes will accelerate in every region

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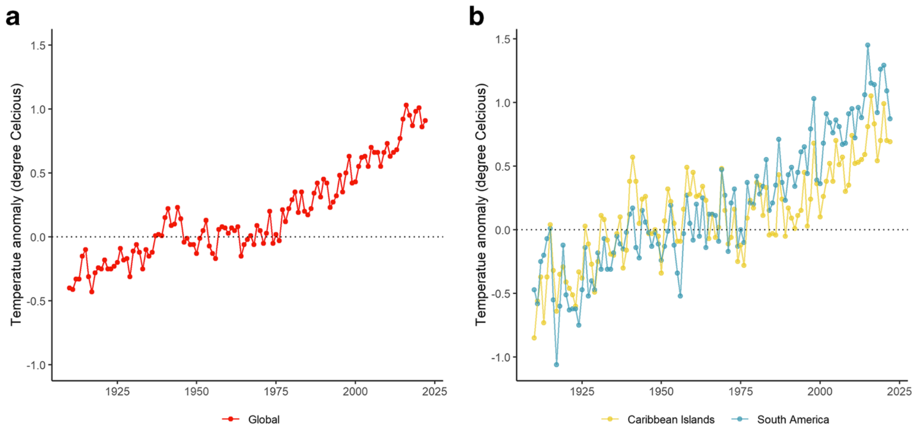

Fig. 1 Global (**A**) and Regional (**B**) Annual Temperature Anomalies 1910–2022. Notes: Anomalies are with respect to the 1901–2000 average. These are surface temperature anomalies averaged over the year considering both land and ocean surface. Source: Authors' calculations based on NOAA National Centers for Evironmental Information

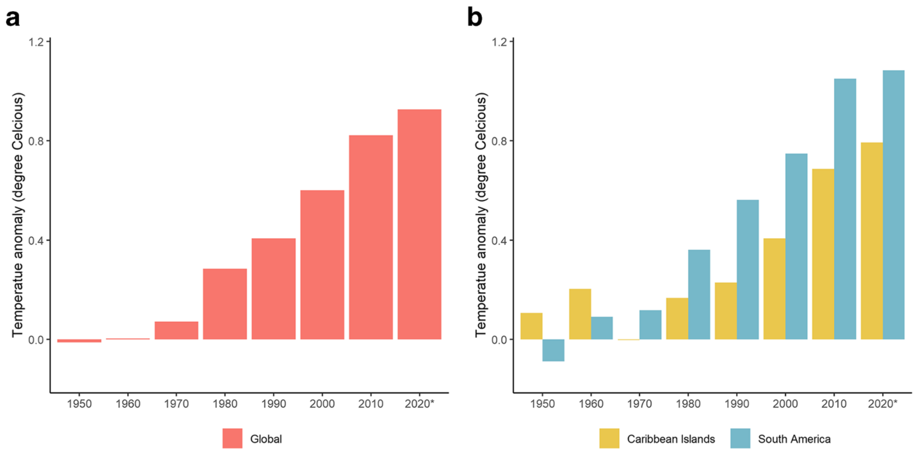

Fig. 2 Global (**A**) and Regional (**B**) average decadal temperature anomalies. Notes: Global anomalies are with respect to the 1901–2000 average, while the regional anomalies are with respect to the 1910–2000 average. These are surface temperature anomalies average over the year considering both land and ocean surface. The 2020 decade considers only three observations: 2020, 2021, and 2022. Source: Authors' calculations based on NOAA National Centers for Evironmental Information

over the next decades (Lee et al. 2021). The World Meteorological Organization (WMO) is predicting that the next few years will be even warmer, with this warming also driven by an emerging El Niño that will exacerbate this trend. WMO (2023) predicts that the annual mean global temperature for each year until 2027 will be between 1.1 °C and 1.8 °C higher than the average over the years 1850–1900.

While rising global temperature is one of the most easily measured indications of anthropogenic climate change, the changes that human emissions of greenhouse gases (GHG) cause to the climate system go far beyond the rising average temperatures. The distributions of temperature and precipitation are also changing, with more extreme temperature and precipitation events occurring almost everywhere. Glaciers and ice sheets are shrinking, and snow is melting earlier (Velicogna et al. 2020; Castellanos et al. 2022). Over the past century, the sea level rose 20 cm and the rate at which sea levels rise has been increasing more recently (Nerem et al. 2018). Extreme weather events, such as heat waves, droughts, and hurricanes, have increased in frequency and severity (Seneviratne et al. 2021; Castellanos et al. 2022).

Given the observed trends, it is evident that climate change will have broad and deep economic impacts. The evidence accumulated so far indicates that these changes will have significant implications for economic growth and other metrics of economic activity.

Climate and weather affect economic production. In Central America and the Caribbean, a 1° Celsius increase in the average annual temperature is estimated to decrease economic output by 2.5% (Hsiang 2010). In the long-term, even relatively small changes in temperature and precipitation can have large negative effects because they affect the level and growth rate of GDP (Dell et al. 2012; Colacito et al. 2019).

Economic growth rates respond non-linearly to total annual rainfall and mean annual temperature (Kotz et al. 2022; Burke et al. 2015). Burke et al. (2015) document an inverted u-shape relationship between temperature and economic growth. Beyond total annual precipitation and mean annual temperature, other changes in the distribution of temperature and precipitation can also impact growth rates. For example, increases in the number of wet days and in extreme daily rainfall decrease economic growth rates (Kotz et al. 2022) and these effects can persist over time.

Weather and climate can also impact economic growth via extreme weather events producing direct and indirect losses. Direct losses are the mortality and morbidity, the destruction of stocks of physical assets, and damages to raw materials and extractable natural resources. Indirect losses refer to the flow of economic activities following the disaster, including impacts on economic growth, consumption, poverty, income inequality and fiscal expenditures and revenues.

An open question is if and how economies that are affected by extreme weather events recover. Answering this question requires studying the indirect losses, particularly the economic growth impacts. Economic theory offers competing hypotheses as to the possible impacts of extreme weather events on GDP growth. The Solow (1956) model, with production functions that exhibit diminishing marginal productivity of capital, would predict higher growth rates in the aftermath of a shock that reduces the capital to labor ratio below the steady state level. Models rooted in a Schumpeterian tradition predict output falling in the aftermath of a shock that depletes labor and capital, but subsequently unleashing the forces of creative destruction leading to higher productivity and growth (Caballero and Hammour 1994). In contrast, in learning-by-doing models, a shock that destroys human and physical capital has persistent negative effects on productivity and growth (Martin and Rogers 1997).

The competing theoretical predictions suggest that assessing the impact on economic growth is ultimately an empirical question. But the empirical estimates available on effects of extreme weather events on economic growth vary in size, direction, and statistical significance. In a meta-study comparing 750 estimates reported in 22 studies, Klomp and Valckx (2014) find negative short-term effects of disasters –encompassing extreme weather events and others— on economic growth (typically in the year of the disaster). The negative effects of disasters on economic growth are most evident in low- and middle-income countries and related to disasters triggered by meteorological and hydrological events (Bertinelli et al. 2012; Felbermayr and Gröschl 2014; Klomp 2016).

Economic Impacts

Macroeconomic estimates using a large sample of disasters with high mortality, including extreme weather events, find that the output *level* drops the year of the disaster between 2 and 4 percentage points on average. Output *growth rates* fall between 2 and 4%, and the recovery after the event is not large enough to catch up with the pre-disaster trends (Borensztein et al. 2017). Using a similar comparative case studies methodology and an updated dataset, Cavallo et al. (2022) find that economies affected by extreme weather events—in their sample of mainly low- and middle-countries—suffer an average permanent loss between 2.1 and 3.7 percentage points of GDP in the aftermath of disasters. In contrast, when the severity of the events is determined by physical intensity rather than by mortality—which implies a more comprehensive sample that includes also high-income countries—the estimated effects on growth were negligible.

Considering the available evidence in this still evolving literature, the emerging consensus is that extreme weather events have, on average, a *negative impact* on short-term economic growth, while the medium to long-run effects remain elusive in general, though several research projects have identified adverse effects in individual cases (Noy and duPont 2018).

The effects of climate on aggregate GDP may mask heterogeneous effects across economic sectors. For instance, temperate countries, such as Chile, may even benefit from rising temperature (Burke et al. 2015). However, even for Chile, disaggregated data show negative effects of higher temperature in several sectors, especially those that depend on the weather as an input into the production process, that expose labor to weather, or that face changes in demand based on weather. Specifically, the agriculture-silviculture, fishing, construction, electricity, gas, and water sectors in Chile suffer from rising temperatures (Hernandez and Madiera 2022). In Central America and the Caribbean, higher temperatures negatively impact the wholesale, retail, restaurant, and hotel sectors (Hsiang 2010), and in the United States, rising summer temperature negatively impacts economic growth in the agriculture, finance, services, retail, wholesale, and construction sectors (Colacito et al. 2019). Overall, however, the evidence indicates that reducing the share of the economy in sectors that are directly exposed to weather is not sufficient to avoid the negative impacts of higher temperatures.

Climate and weather affect all components of economic production. Temperature affects labor, capital, and total factor productivity, with particularly large impacts on total factor productivity (Henseler and Schumacher 2019; Orlov et al. 2021). Temperature has an inverted u-shape relationship with firm-level total factor productivity in both capital-intensive and labor-intensive firms (Zhang et al. 2018). Higher temperature also reduces labor supply and labor productivity (Graff Zivin and Neidell 2014; Cachon et al. 2012).

At the aggregate level, these extreme events may also have an impact on trade (Osberghaus 2019). Mohan (this issue) examines this question for a group of countries that are especially vulnerable and exposed to hurricanes: The Small Island Developing States (SIDS) of the Eastern Caribbean. Mohan finds that indeed hurricanes reduce both exports and imports in these SIDS during the immediate aftermath of a hurricane strike. Maybe reassuringly, she also finds that trade flows recover rapidly, within a few months. The Eastern Caribbean SIDS are heavily dependent on trade for basic needs, and are geographically proximate to their main trading partners, and this may explain why trade flows recover so quickly.

Beyond these immediate adverse impacts, higher temperature decreases educational attainment and test scores (Graff Zivin et al. 2018; Garg et al. 2020). If persistent, this could lead to productivity losses in the future. There is significant evidence that these adverse impacts on human capital are possibly long lasting maybe even inter-generationally (Caruso 2017; Caruso et al. 2023). In Ecuador, for example, individuals exposed to higher-than-average temperature in utero have lower educational attainment (Fishman et al. 2019). Persistently higher temperatures could also lower human capital accumulation and the quality and quantity of labor supply indirectly through lower incomes and its associated adverse health impacts (Garg et al. 2020).

Weather and climate also affect the stock of capital needed to support economic production. Changes in temperature and precipitation and extreme weather events reduce investment and destroy productive capital. By one estimate, investment is 6 percent lower six years after a 1° Celsius temperature shock (Acevedo et al. 2020). One channel through which weather and climate changes can lead to a lower stock of productive assets is through lower contemporaneous economic output, which reduces the resources available to invest and can induce sales of productive assets to smooth consumption.

Low-income countries bear an unequal share of the impacts of climate change and disasters (Hallegatte et al. 2020). The inverted u-shape relationship between temperature and economic growth found in Burke et al. (2015) implies that, overall, cooler countries will benefit from a warmer climate and warmer countries will suffer (Burke et al. 2015). Because many high-income countries are located at higher latitudes with cooler climates, the negative economic impacts of rising temperature will be concentrated in low- and middle-income countries that are located closer to the tropics, exacerbating economic inequality across countries (Diffenbaugh and Burke 2019; Acevedo et al. 2020). Similarly, low-income countries represent 74% of the world's population but suffer 93% of the mortality from disasters, including from extreme weather events (Cavallo and Noy 2011). Further, the negative macroeconomic impacts of disasters on economic growth are larger for poorer countries, suggesting that the impact of extreme weather events on growth is an economic development issue (Cavallo et al. 2022).

A paper that has attempted to shed some light on the future aggregate risk implications of disasters (in this case, hurricanes) on smaller and poorer countries in the Caribbean is van Oosterhout et al. (this issue). The paper focusses on the small Dutch Caribbean Island territory of Bonaire. Using the Shared Socioeconomic Pathways (SSP) scenarios that were developed in IPCC reports, in combination with a detailed and nuanced information about the island's economic activity, the paper examines the impact of climate change on the most relevant macro-economic metrics. This detailed scenario assessments can provide the government of Bonaire the opportunity to more carefully assess the various alternative adaptation intervention approaches that might be relevant and feasible in this specific case. This analysis also suggests that a similar methodological approach can be developed for other SIDS in the region.

Determinants of Direct Losses

One critical factor that determines the extent of direct losses is the physical intensity of the event. There is a scientific consensus that as the oceans warm, there will be more moisture in the atmosphere causing hurricanes, floods, and storms to be more frequent and severe in many locations around the world. But economic factors, for which low-income countries are at a disadvantage, also play a role in determining the extent of direct losses from extreme weather events. The level of economic development and country size tend to be positively correlated with the monetary cost of losses because in richer and larger countries more wealth is exposed. However, the same factors tend to be negatively associated with mortality because richer countries can usually afford better preparedness (Cavallo and Noy 2011). Moreover, richer and larger countries tend to have more diversified economies and thus, can engineer the inter-sectoral and inter-regional transfers required to reduce the indirect economic losses from extreme weather events. Large and rich countries, for example, can more easily absorb output shocks from disasters originating in smaller geographic regions within the country (Auffret 2003). In contrast, small-island states in the Caribbean are particularly vulnerable as a disaster typically affects the whole country.

Other economic factors affecting the extent of direct losses relate to the political economy of disaster prevention. Inequality, for example, is an important determinant of prevention efforts: more unequal societies tend to spend fewer resources on prevention as they appear unable to resolve the collective action problem of implementing preventive and mitigating measures (Anbarci et al. 2005).[1] This suggests that in more unequal countries, outside actors, such as multilateral development banks, philanthropic organizations, or other donors, can play a role in persuading policymakers to invest in risk reducing measures to protect poor and vulnerable populations. Policy interventions that help improve preparedness can reduce the number of people affected and the direct and indirect losses from disasters, especially among the most vulnerable groups.

Climate change and extreme weather events also exacerbate poverty and inequality *within* a country. At the household level, indirect losses from extreme weather events include the loss of income resulting from the non-provision of goods and services, or from the destruction of previously used means of production (i.e., fisheries, forests, agriculture, among others). Low-income households are particularly vulnerable because they have fewer insurance mechanisms available to protect themselves (Rodriguez-Oreggia et al. 2013). Poor people are exposed to risks more frequently, lose a greater share of their wealth when disasters hit, and have less access to financial resources to confront the emergency (Hallegatte and Rozenberg 2017). The disproportionate impacts on the poor can be exacerbated if the relief and reconstruction efforts in the aftermath of disasters are not well targeted and, as a result, do not provide relief to the most vulnerable groups.

Zapata (this issue) provides additional evidence on the impact of disasters – in his case, extreme weather events – on inequality in Ecuador. Using a decade-long panel dataset of aggregate economic activity at the municipality level, Zapata explores what happens to a municipality's income inequality when it is hit by a weather disaster. He finds that the adverse impact he identifies on income inequality is largely driven by the damage these extreme weather events cause to public infrastructure (rather than the mortality or damage to private property they wreak). This both describes a vicious cycle of increasing inequality and increasing disaster risk, and equally suggests a role for policy in creating a virtuous cycle of reduced inequality and increasing resilience.

[1] In a similar vein, Besley and Burgess (2002) observe that flood impacts in India are negatively correlated with newspaper distribution; they attribute this effect to the fact that when circulation is higher, politicians are more accountable, and the government is more active in both preventing and reducing the impacts of disasters. Eisensee and Strömberg (2007) reach similar conclusions regarding the response of U.S. disaster aid to media reports.

A further exploration of the interactions between inequalities and disadvantage, and weather shocks, is provided by Pérez et al. (this issue). They focus on a specific hazard, droughts, and rural populations in the North and South of Chile. Their paper uses individual-level survey data from communities in both regions to examine the impact of droughts on reported income and labour market activity. They find that while women more generally do not appear to suffer decreases in income for droughts, it is indigenous women that are vulnerable and do experience these declines. This (intersectionally) disadvantaged population experiences decreasing income, a lower probability of working in agriculture, an increase in the likelihood of working as an unpaid family worker, or not working at all.

Fiscal Issues

Latin America and Caribbean governments typically must spend substantial unbudgeted resources for the emergency response and for recovery and reconstruction (even net of any international aid received). This is needed even while revenues may fall, which inevitably leads to increased sovereign borrowing and higher debt levels.

These dynamics can weaken the government's fiscal accounts, increase public debt, and force the government to defer, or abandon planned public investment. Alejos (2018) estimates that the occurrence of at least one extreme event each year is associated with an increase in the fiscal deficit of 0.8% of GDP for lower-middle income countries and of 0.9% of GDP for low-income countries. Most of this negative effect on the budget balance comes from a decrease of government revenues. For lower-middle and low income countries, this decline in revenues is equivalent to 0.8% and 1.1% of GDP, respectively. In contrast, the contemporaneous effect on public expenditure is limited and, for low-income countries, spending may decline (i.e., is pro-cyclical) due to binding credit constraints in the public sector. Combining these estimates with the frequency of disasters in the region, the average annual fiscal cost of extreme weather events in the region was between 0.2% and 0.3% of GDP for the 2001–19 period. This represents more than 10% of the average fiscal deficit (2.6%) in those years.

To address the adverse fiscal implications resulting from the detrimental effects of severe climatic events, Cavallo and Hoffmann (2020) suggest strategies that enable governments to pursue counter-cyclical fiscal policies after disasters. One such strategy is the pooled parametric insurance scheme that was initiated in the Caribbean in 2007 – the Caribbean Catastrophic Risk Insurance Facility (CCRIF). Hochrainer-Stigler et al. (this issue) analyse the ability of the CCRIF scheme to alleviate the fiscal pressures that result from hurricane strikes in the Caribbean. They develop a 'storyline' approach in which historical scenarios—e.g., the 2017 hurricane season that included the three catastrophic storms of Irma, Harvey and Maria – are assumed to be even more damaging. This storyline scenario's impact on the fiscal accounts is then investigated, including an accounting for any payment from CCRIF that may hypothetically be forthcoming. As such, their paper finds that the CCRIF cover can indeed alleviate the short-run post-hurricane fiscal pressures. Of course, this reliance on a specific storyline approach, more akin to the stress-testing exercises often imposed by bank supervisors, does not permit a full-scale assessment of the CCRIF scheme, its efficiency, and its viability. However, it does allow a consideration of the changes – many of them unfortunate – brought about by climate change. In this context, especially noteworthy is the Hochrainer-Stigler et al. inability to fully assess individual countries access to the CCRIF (in the past and the present), as the information about their specific contractual arrangements is not publicly available (a curious choice, given the nature of the scheme and its funding sources).

Adaptation

The last question being asked in this special issue is about adaptation. Noy and Strobl (2022) have shown that increasing heat, and particularly heatwaves, engender more innovation in cooling technology (specifically, air conditioning). It is likely, and maybe intuitively obvious, that warmer temperatures will also lead to more adoption of these cooling technologies by households. Specifically, one can ask whether households adjust to the rising temperatures by increasing their use of air conditioning, and further what can we deduce about the speed of adoption of this technology and, equally importantly, its distributional implications.

The task of answering these questions is undertaken by McRae (this issue) who uses detailed high-frequency household electricity billing data from Colombia. McRae finds that it is wealthier households that adopt this technology faster and use it more when temperatures increase. Less wealthy households appear to be less likely to use this technology, even if they have access to it, probably motivated by its high use costs. More optimistically, lower-income households seem to be increasingly adopting air conditioning technology, too; they are thus converging toward the use rates that are observed for higher-income households.

Conclusion

In conclusion, the intricate connections between climate change and socioeconomic issues in Latin America and the Caribbean require rigorous scrutiny. This special issue has shed light on some of the most pressing concerns, revealing that climate change is not only an environmental crisis, but also a significant economic one with far-reaching implications for growth, poverty, inequality, and fiscal stability in the region. The studies presented here offer a critical stepping stone, providing valuable insights that could inform policymakers and stakeholders as they navigate these complex challenges. Nonetheless, numerous unanswered questions that warrant further investigation remain. As the region continues to grapple with these issues, ongoing research will be of paramount importance in the quest for resilient, equitable, and sustainable strategies that can alleviate the multifaceted impacts of climate change on Latin America and the Caribbean.

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