

# The link between physical climate risk and sovereign default

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Many countries have experienced significant economic losses associated with extreme weather events and chronic climate-related stress over the last few decades. Examples can be found on every continent. Hurricane Mitch left ~3 million people in Honduras homeless in 1998,<sup>1</sup> the heat wave in Europe caused estimated losses of over 13 billion euros in 2003;<sup>2</sup> flooding in Thailand led to a reduction in the country's Gross Domestic Product (GDP) of over 4% in 2011;<sup>3</sup> and wildfires in Australia are estimated to have cost almost \$100B in damage in Australian dollars in 2019 and 2020 season.<sup>4</sup> As immense as they are, these losses do not represent the full scope of the potential impacts of climate change on health, productivity, geopolitical tension, domestic politics, political stability, civil unrest, human migration, food security, and natural capital.

These challenges are not going away. Under realistic emissions scenarios, the impacts of climate change are projected to intensify over the next few decades, and the impacts on sovereign nations' fiscal stability and economic security are likely to be profound.

For many countries, sovereign debt plays a critical role in fiscal planning, infrastructure funding, and disaster response. For other countries, especially low-income countries forced to borrow at high rates, debt service payments can hamper economic recovery and development over the long-term. According to the United Nations, at least 45 countries are currently spending more on interest payments to creditors than they are on healthcare, and at least 19 developing countries are spending more in interest than on education. Together almost half the world's population – ~3.3 billion people – live in countries that pay more in debt service than they do on health or education services.<sup>5</sup> At the most extreme end, several low-income countries pay well over 10% of their national budgets in debt service.<sup>6</sup> These payments represent transfers of wealth from developing countries to developed economies that often rival or exceed the aid flowing the other way.<sup>7</sup>

<sup>1</sup> Beaubien, J. (Dec. 14, 2020). Even Disaster veterans are stunned by what's happening in Honduras. NPR.

Available at [npr.org/sections/goatsandsoda/2020/12/14/945377248/even-disaster-veterans-are-stunned-by-whats-happening-in-honduras](https://www.npr.org/sections/goatsandsoda/2020/12/14/945377248/even-disaster-veterans-are-stunned-by-whats-happening-in-honduras)

<sup>2</sup> Impacts of summer 2003 heat wave in Europe (Accessed Nov. 17, 2023). Environmental Alert Bulletin, United Nations Environment Programme.

Available at [unisdr.org/files/1145\\_ewheatwave.en.pdf](https://unisdr.org/files/1145_ewheatwave.en.pdf)

<sup>3</sup> Tanoue M, Taguchi R, Nakata S, Watanabe S, Fujimori S, Y Hirabayahsi (2020). Estimation of Direct and indirect economic losses caused by a flood with long-lasting inundation: Application to the 2011 Thailand Flood. Water Resources Research 56(5).

<sup>4</sup> Read, P & R Denniss (Jan. 16, 2020). With costs approaching \$100 billion, the fires are Australia's costliest natural disaster. The Conversation.

Available at [theconversation.com/with-costs-approaching-100-billion-the-fires-are-australias-costliest-natural-disaster-129433#](https://theconversation.com/with-costs-approaching-100-billion-the-fires-are-australias-costliest-natural-disaster-129433#)

<sup>5</sup> A World of debt: A growing burden to global prosperity (2022). The United Nations Conference on Trade and Development.

Available at [unctad.org/publication/world-of-debt](https://unctad.org/publication/world-of-debt)

<sup>6</sup> Press Release (Apr. 3, 2023). Low-income countries using of 10% of budgets to service debts. International Institute for Environment and Development.

Available at [iied.org/low-income-countries-using-over-10-budgets-service-debts](https://iied.org/low-income-countries-using-over-10-budgets-service-debts)

<sup>7</sup> Hickel, J (2017). Aid in reverse: how poor countries develop rich ones. The Guardian.

Available at [theguardian.com/global-development-professionals-network/2017/jan/14/aid-in-reverse-how-poor-countries-develop-rich-countries](https://theguardian.com/global-development-professionals-network/2017/jan/14/aid-in-reverse-how-poor-countries-develop-rich-countries)

The borrowing costs and debt burdens of many countries could prove to be unsustainable over the long-term. The World Bank and the International Monetary Fund estimate that 60% of low-income countries are in “debt-distress” and at risk of being unable to fulfill their debt service obligations as of 2023.<sup>8</sup> Many of these countries are exposed to significant physical climate risk and face a dual debt-climate challenge: mitigation and adaptation (not to mention recovery) efforts require significant upfront investment. Country-level adaptations have been found to reduce damage and fatalities from tropical cyclones (though the degree of the estimated protective effect varies significantly between studies).<sup>9,10</sup> Countries that have tried to make their economies more resilient to climate change may also have slightly lower sovereign borrowing costs.<sup>11,12</sup> Yet for low-income countries, the investment required to fund adaptation projects often comes at very high costs on the sovereign bond market – costs that may only increase if the country experiences a natural disaster or climate shock.<sup>13</sup>

To enable market participants to understand the risks facing sovereign nations in the future, ICE Sustainable Finance has developed Physical Risk Scores based on state-of-the-art global climate models and projected loss estimates. Below we present an analysis of the default histories of more than 190 countries over a 25-year period, establishing a clear quantitative link between climate risk and sovereign default risk even after accounting for a suite of economic indicators. Our goal is to inform market participants and stakeholders about the implications of climate risk for international debt markets, with a particular focus on the challenges facing the world’s most climate-vulnerable countries.

## Key points

- The ICE Physical Risk Score quantifies the physical climate risks of sovereign nations around the world based on state-of-the-art global climate models of chronic climate-related stress out to 2080.
- These scores are easy to interpret: a score of 5 represents sovereign nations with extremely high physical risk, and a score of 0 represents sovereign nations with low physical climate risk.
- An ICE Sustainable Finance analysis of sovereign defaults between 1995-2020 found that after controlling for a suite of development and economic indicators, countries with high ICE Physical Risk Scores have higher default probabilities than countries with low scores. Holding all else constant, a country with an ICE Physical Risk Score of 5 is associated with a 18.5% higher probability of default on average than a country with an ICE Physical Risk Score of 0. Said another way, after accounting for economic indicators, sovereign default probability increases by 3.7% on average for each one unit increase in the ICE Physical Risk Score.
- Many low-income countries are facing a dual debt-climate challenge. The last section of the paper focuses on ideas for options to make the sovereign debt market more sustainable for all participants.

<sup>8</sup> Sovereign Debt Concerns in Developing Countries (Mar. 6, 2023). Congressional Research Service “In Focus” Report, Available at [sgp.fas.org/crs/row/IF11880.pdf](https://sgp.fas.org/crs/row/IF11880.pdf)

<sup>9</sup> Bakkensen, LA & R Mendelsohn (2016). Risk and Adaptation: Evidence from Global Hurricane Damages and Fatalities. *Journal of the Association of Environmental and Resource Economists* 3(3). [doi.org/10.1086/685908](https://doi.org/10.1086/685908). Available at [laurabakkensen.com/wp-content/uploads/2016/01/Risk-and-Adaptation.pdf](https://laurabakkensen.com/wp-content/uploads/2016/01/Risk-and-Adaptation.pdf)

<sup>10</sup> Hsiang S & D Narita. (2012). Adaptation to cyclone risk: evidence from the global cross-section. *Climate Change Economics* 3(2), 1250011.

<sup>11</sup> Beirne J, Renzhi N & U Volz. Feeling the heat: climate risks and the cost of sovereign borrowing. *International Review of Economics and Finance*, 76, 920-936.

<sup>12</sup> Cevik S, Jalles J (2020) This Changes Everything: Climate Shocks and Sovereign Bonds. In: IMF Working Paper No. 20/79. International Monetary Fund, Washington, DC

<sup>13</sup> Kraemer, M. M. Mrsnik, A. Petrov, & B.S. Glass. 2015. Storm Alert: Natural Disasters Can Damage Sovereign Credit Worthiness. S&P Global Ratings. Accessed Sept. 9, 2023.



# ICE Physical Risk Scores

The ICE Physical Risk Score quantifies the risks to sovereign nations associated with chronic climate stress and extreme heat, incorporating the potential impacts of climate change on productivity, crops, and human health around the world. The score is based on six measures of climate physical risk and vulnerability from ICE Sustainable Finance’s global heat and drought models, combined with projections of water stress from the Water Resources Institute.<sup>14</sup> The six ICE Sustainable Finance measures of climate physical risk and vulnerability are historical estimates and future projections at the country level of the following:

**Cooling degree days**

The total number of degrees that average daily temperatures rise above 18°C over the course of a year

**Heating degree days**

The total number of degrees that average daily temperatures rise fall below 18°C over the course of a year

**Killing degree days**

The total number of degrees that average daily temperatures rise above 30°C during crop growing seasons

**Excess mortality**

Number of additional deaths among vulnerable populations<sup>15</sup> per 100,000

**Productivity losses due to the effects of extreme heat on workers**

Measured as percent losses

**GDP losses due to decreased productivity**

Measured as percent losses

Projections of water stress, the ratio of total water withdrawals to available renewable surface and groundwater supplies, from the Water Resources Institute’s global water stress models, are also incorporated.

Together, the seven measures of climate risk and vulnerability are combined to create a single ICE Physical Risk Score for each country using Principal Component Analysis (PCA), a widely used mathematical technique that identifies and isolates the dominant signals within large and complex datasets. The final scores range from 0 to 5, where a higher score indicates greater climate risk. ICE currently calculates Physical Risk Scores for 196 independent countries and 46 other territories, dependencies, disputed areas, and areas of special sovereignty.<sup>16,17</sup> They are available historically (based on losses estimated from observations over the period 1980-2018) and projected into the future from 2030 to 2080. Projected future scores are provided for three different emissions scenarios: Shared Socioeconomic Pathways (SSPs) SSP1-2.6 (the “Sustainability” pathway, with global emissions declining to net-zero by 2050), SSP3-7.0 (the “Regional Rivalry” pathway, with global emissions roughly doubling by 2100), and SSP5-8.5 (the “Fossil-fueled development” pathway, with global emissions roughly doubling by 2050).

Under all three climate scenarios, the projected ICE Physical Risk Scores increase over time. The global average historical score is 1.5. No country has a historical score greater than 4. Looking to 2080, the global average ICE Physical Risk Score is projected to increase under all scenarios (a 0.6-increment increase under SSP1-2.6, a 1.7- increment increase under SSP3-7.0, and a 2.1-increment increase under SSP5-8.5). By 2080, under the lowest-emissions scenario (SSP1-2.6), there are 19 countries with projected ICE Physical Risk Scores above 4; under the highest emissions scenario (SSP5-8.5), this number increases to 109 – over half of countries.

<sup>14</sup> The Water Resources Institute, Aqueduct 4.0 Current and Future Global Maps Data. Available at [wri.org/data/aqueduct-global-maps-40-data](http://wri.org/data/aqueduct-global-maps-40-data)

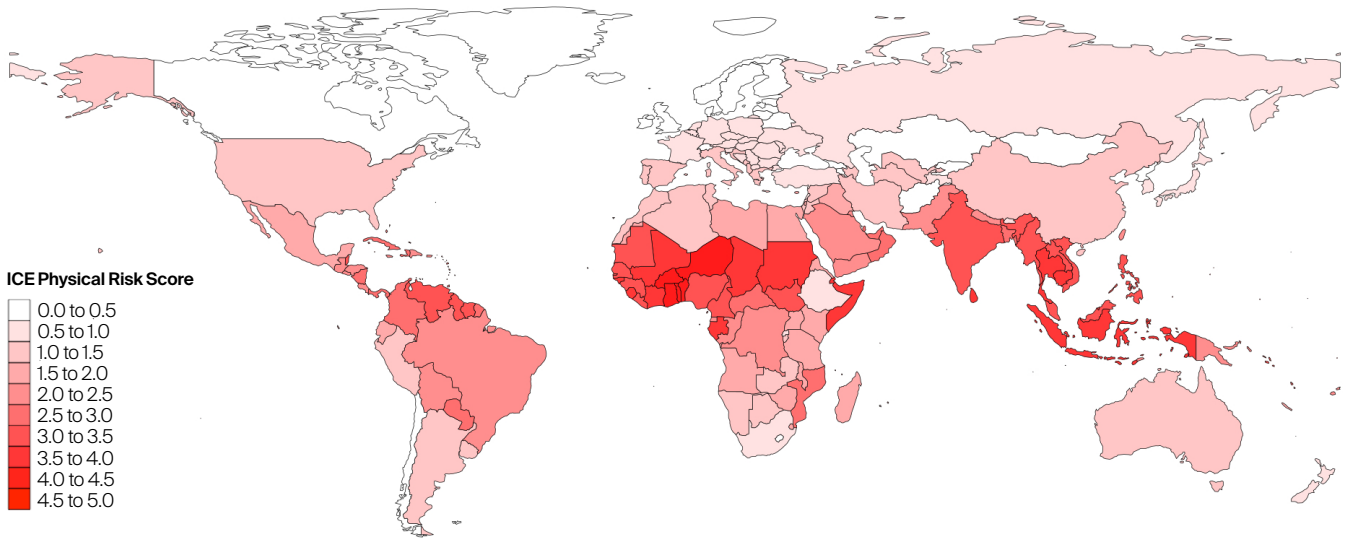
<sup>15</sup> The elderly (>65 years old) and the young (<6 years old).

<sup>16</sup> Though ICE Sustainable Finance calculates Physical Risk Scores for a total of 242 countries, territories, dependencies, disputed areas, and areas of special sovereignty, all numbers and results presented in this analysis are based on 196 countries designated as independent by the U.S. Department of State as of Nov. 1, 2023 (See citation below). Territories Guam and the U.S. Virgin Islands have their own Physical Risk Scores, but we did not include them in this analysis because they are not sovereign nations. The only exception is Figure 1, which does include scores for all 242 countries, territories, dependencies, disputed areas, and areas of special sovereignty on the map.

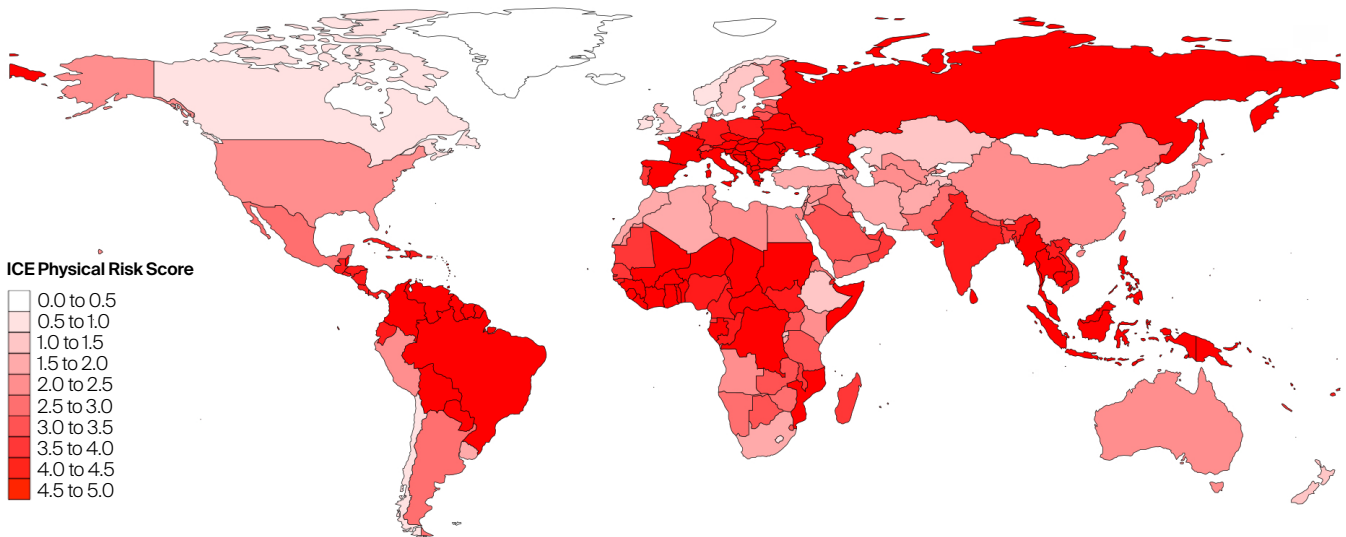
<sup>17</sup> Fact Sheet. (Oct. 2, 2023). Independent States in the World, Bureau of Intelligence and Research, U.S. Department of State (Accessed Nov. 1, 2023). Available at [state.gov/independent-states-in-the-world](http://state.gov/independent-states-in-the-world)



2030



2080



**Figure 1:** The ICE Physical Risk Scores under SSP5-8.5 in 2030 and 2080  
**Source:** ICE Sustainable Finance as of 10/30/2023

By 2080, ICE Physical Risk Scores are projected to be extremely high (>4) across much of Europe, South and Central America, South Asia, and Central Africa (Figure 1). These scores reflect not only increased heat projections for these regions, but also the vulnerability of these countries' economies and populations to heat-related perils. ICE Sustainable Finance productivity loss projections, for example, incorporate information about both future heat projections and the numbers of workers in industries that are highly exposed to heat in each country, as well as the average metabolic rate of the work (essentially, the average strenuousness) within each industry. ICE Sustainable Finance's excess mortality projections similarly incorporate information about each country's climate zone and income level.

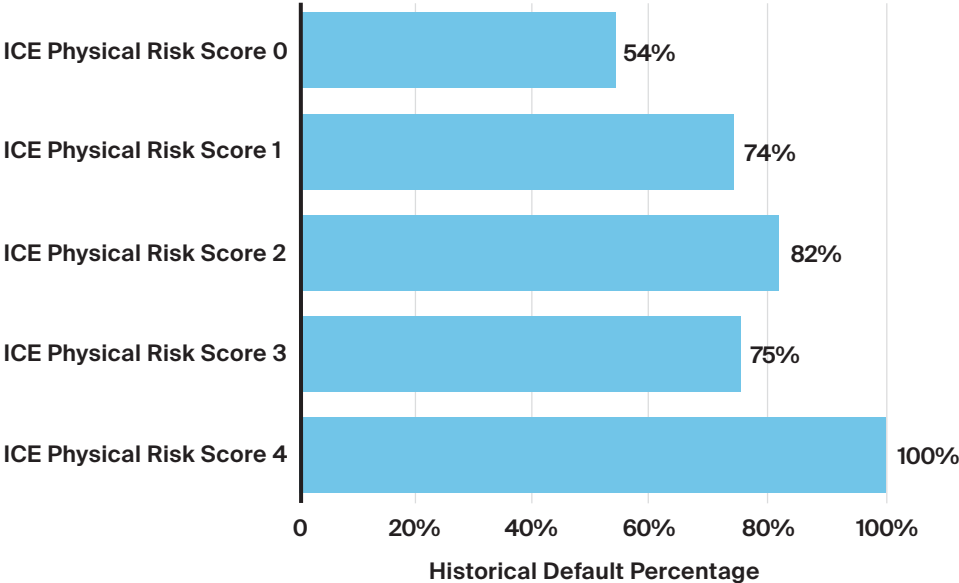
The importance of including vulnerability considerations in climate risk projections is clear from the historically fatal toll of heat waves in countries that were not prepared for high temperatures. In 2003, a heat wave in Europe is estimated to have killed more than 30,000 people, with temperatures soaring above 40 degrees Celsius across France, the UK, Germany, and Spain – countries in which few households had air conditioning.<sup>18</sup> Seven years later, in 2010, a 44-day heat wave in Russia was associated with over 10,000 excess deaths.<sup>19</sup>

<sup>18</sup> Impacts of summer 2003 heat wave in Europe (Accessed Nov. 17, 2023). Environmental Alert Bulletin, United Nations Environment Programme. Available at [unisdr.org/files/1145\\_ewheatwave.en.pdf](https://unisdr.org/files/1145_ewheatwave.en.pdf)

<sup>19</sup> Shaposhnikov, D, Revich, B, Bellander, T, Bedada, G, Bottai, M, Kharkova, T, Kvasha, E, Lezina, E, Lind, T, Semutnikova, E & Pershagen, G. (2014). Mortality related to air pollution with the Moscow heat wave and wildfire of 2010, *Epidemiology*, 25(3), 359-64. doi: 10.1097/EDE.000000000000090



Countries with high ( $\geq 3.0$ ) historical ICE Physical Risk Scores—Benin, Nigeria, Niger, Sierra Leone, Somalia, Ghana, Sri Lanka, and Burkina Faso, among others – have also experienced numerous natural disasters related to climate in recent years. In 2009, floods in western Africa affected over 400,000 people;<sup>20</sup> a drought that began in 2020 in Kenya, Somalia, and Ethiopia killed millions of livestock;<sup>21</sup> flooding in Nigeria in 2022 displaced about 2.5 million people and caused hundreds of casualties, injuries, and extensive property damage;<sup>22</sup> and a recent drought in Sri Lanka put further strain on the nation’s economy.<sup>23</sup>



**Figure 2:** The percentage of countries that have defaulted at least once between 1995 and 2020 as a function of their historical ICE Physical Risk Scores. Of the seven countries with historical ICE Physical Risks Scores close to 4 (greater than or equal to 3.5), all have defaulted at least once. There are no countries with historical ICE Physical Risk Scores > 4. In this analysis, a country is considered to be ‘in default’ in any given year if any non-zero portion of government debt is in default. **Source:** ICE Sustainable Finance as of 10/23/2023 and The Bank of Canada and Bank of England Sovereign Default Database<sup>24</sup>

Given the scale of these climate-related impacts, it is perhaps not surprising that countries with higher historical ICE Physical Risk Scores also tend to have higher rates of sovereign default (Figure 2). Every one of the seven countries with historic ICE Physical Risk Scores greater than or equal to 3.5 has defaulted at least once between 1995 and 2020. Over the same period, 75% of the 37 countries with historic ICE Physical Risk Scores greater than or equal to 2.5 and less than 3.5 have defaulted. In order to gain a more robust understanding of the link between physical climate risk and sovereign default probability, ICE Sustainable Finance built a series of default models that incorporate climate risk while controlling for key economic indicators.

<sup>20</sup> Floods across the Western Sahel (Sept. 6, 2009, Accessed Nov. 17, 2023). NASA Earth Observatory. Available at [earthobservatory.nasa.gov/images/40127/floods-across-the-western-sahel](https://earthobservatory.nasa.gov/images/40127/floods-across-the-western-sahel)  
<sup>21</sup> World Meteorological Organization (May 20, 2022). Press Release: Meteorological and humanitarian agencies sound alert on East Africa. Available at [public.wmo.int/en/media/news/meteorological-and-humanitarian-agencies-sound-alert-east-africa](https://public.wmo.int/en/media/news/meteorological-and-humanitarian-agencies-sound-alert-east-africa)  
<sup>22</sup> Usigbe, L. (Aug. 2023). Nigeria prioritizes climate action to mitigate natural disasters. The United Nations General Assembly 2023, Africa Renewal. Available at [un.org/africarenewal/magazine/august-2023/nigeria-prioritizes-climate-action-mitigate-natural-disasters](https://un.org/africarenewal/magazine/august-2023/nigeria-prioritizes-climate-action-mitigate-natural-disasters)  
<sup>23</sup> Jayasinghe, U (Aug. 29, 2023). Drought dents Sri Lanka’s economic hopes, farmers’ livelihood. Reuters. Available at [reuters.com/world/asia-pacific/drought-dents-sri-lankas-economic-hopes-farmers-livelihood-2023-08-29](https://reuters.com/world/asia-pacific/drought-dents-sri-lankas-economic-hopes-farmers-livelihood-2023-08-29)  
<sup>24</sup> BoC-BoE Sovereign Default Database: What’s new in 2023? (Jul. 2023). Accessed Nov. 17, 2023. Data available for download at [bankofcanada.ca/2023/07/staff-analytical-note-2023-10](https://bankofcanada.ca/2023/07/staff-analytical-note-2023-10)

## The link between physical risk and marginal default risk

Though historic default rates tend to be higher for countries with more physical climate risk (Figure 2), a more comprehensive understanding of the relationship between default rate and physical climate risk needs to account for economic factors that can also influence a country's default likelihood. To model the relationship between the economic conditions, climate risk, and default probabilities of countries across the world, ICE Sustainable Finance uses 25 years of historical default data from the Bank of Canada<sup>25</sup> (1995-2020) along with economic indicators from the World Bank's World Development Indicators (WDI)<sup>26</sup> (1990-2020) to build a probability of default model for sovereigns. In any given year, a country is considered to be 'in default' if any non-zero portion of government debt is in default. For the 196 countries included in this analysis, historical defaults are modeled as a function of seven WDI metrics:

1. Inflation (the increase in prices over time)
2. Terms of trade index (the relative prices of a country's exports and imports)
3. Real effective exchange rate (the value of a country's currency relative to an index or group of major currencies)
4. GDP deflator (the ratio of nominal GDP to real GDP)
5. GDP Growth (the percentage change in a country's GDP over time)
6. Debt-to-GDP Ratio (the proportion of a country's debt relative to its GDP)
7. Domestic credit (the amount of credit provided by a country's financial sector)

For every year from 1995 to 2020, ICE Sustainable Finance calculated a 5-year lagged average of these seven economic indicators and used these values to predict the likelihood of default in the following year. This resulting model serves as the control model because it incorporates only economic factors. A second model, referred to as the climate model, was then built that includes both the economic indicators and the historical value of each country's ICE Physical Risk Score. The difference in predicted probability between the control and the climate models represents the increased likelihood of default that can be associated with climate risk. Holding all seven economic variables constant, the models suggest that sovereign default probability increases by 3.7% on average for each one unit increase in the ICE Physical Risk Score.

Put another way, ICE Sustainable Finance's default models suggest that given the same set of seven economic indicators, a country with an ICE Physical Risk Score of 5 might be expected to have a 18.5% higher probability of default in a given year on average, compared to a country with an ICE Physical Risk Score of 0.

**Holding all else constant, a one-increment increase in a country's ICE Physical Risk Score is associated with an increase of in sovereign default probability of 3.7%**

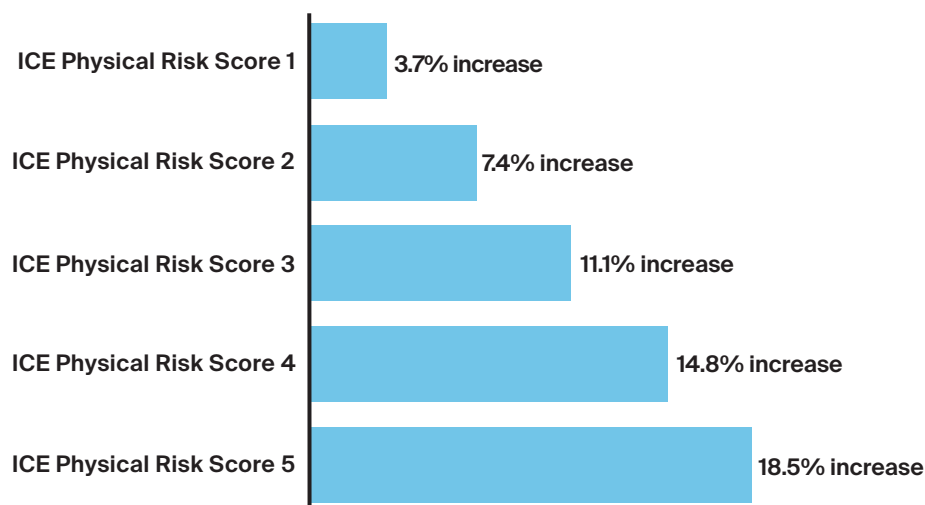
<sup>25</sup> BoC-BoE Sovereign Default Database: What's new in 2023? (Jul. 2023). Accessed Nov. 17, 2023.

Data available for download at [bankofcanada.ca/2023/07/staff-analytical-note-2023-10](https://bankofcanada.ca/2023/07/staff-analytical-note-2023-10)

<sup>26</sup> World Development Indicators, World Bank, 1990-2020. (Accessed Nov. 17, 2023). Available at [databank.worldbank.org/source/world-development-indicators](https://databank.worldbank.org/source/world-development-indicators)



## Cumulative increase in default probability relative to ICE Physical Risk Score of 0



**Figure 3:** Cumulative predicted increase in probability of sovereign default associated with increasing the ICE Physical Risk Score  
**Source:** ICE Sustainable Finance as of 10/23/2023

These results are broadly consistent with the academic literature on the relationship between natural disasters, debt levels, and the default risk of sovereign nations. Major storms, for example, have been shown to increase the likelihood of sovereign default and raise the sovereign default premiums of affected countries.<sup>27,28</sup> Public debt growth of developing countries also tends to be 2.3-3.6% higher in the three years following a natural disaster compared to the debt growth of countries that did not experience a disaster.<sup>29</sup> Temperature shocks, measured by comparing average monthly temperatures to historical averages, have also been linked to lower sovereign bond performance in emerging market countries with warmer climates and low seasonality, suggesting that these countries may face higher borrowing costs in the future.<sup>30</sup>

There are also several recent studies on the impacts of physical climate vulnerability on individual countries' positions within the sovereign debt market. Like ICE Sustainable Finance's default models (Figure 2), these studies do not consider impacts of natural disasters after the fact; they instead focus on the effects of countries' vulnerability to future disasters. Climate vulnerability has been associated with higher sovereign borrowing costs<sup>31,32,33</sup> and a one percentage point increase in climate vulnerability has been linked to a ~0.4% increase in sovereign default probability.<sup>34</sup> Importantly, many previous studies are based on the University of Notre Dame's ND-GAIN Climate Vulnerability Index, which incorporates both socioeconomic factors and physical risk exposure. The ICE Sustainable Finance's sovereign default model (Figure 3) takes a similar approach to the last of these studies,<sup>35</sup> but is distinct in that it focuses exclusively on the association of physical climate risk with sovereign default and incorporates more countries over a slightly longer period.<sup>36</sup>

<sup>27</sup> Klomp, J. (2015). Sovereign risk and natural disasters in emerging markets. *Emerging Markets Finance and Trade*, 51(6):1326-1341

<sup>28</sup> Klomp, J. (2017). Flooded with debt. *Journal of International Money and Finance*, 73:93-103

<sup>29</sup> Fan, RY, Lederman, D, Nguyen, H & Rojas, CJ (2023) Calamities, Debt and Growth in Developing Countries.

IMF Economic Review [doi.org/10.1057/s41308-023-00200-3](https://doi.org/10.1057/s41308-023-00200-3).

<sup>30</sup> Boehm, H. (2022) Physical Climate change and the sovereign risk of emerging economies. *Journal of Economic Structures*. 11:31

<sup>31</sup> Beime, John and Renzhi, Nuobu and Volz, Ulrich, Feeling the Heat: Climate Risks and the Cost of Sovereign Borrowing (June 30, 2020). ADBI Working Paper 1160, Available at SSRN [ssrn.com/abstract=3657114](https://ssrn.com/abstract=3657114) or <http://dx.doi.org/10.2139/ssrn.3657114> [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3657114](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3657114)

<sup>32</sup> Kling, Gerhard and Lo, Yuen and Murinde, Victor and Volz, Ulrich, Climate Vulnerability and the Cost of Debt (June 18, 2018).

Available at SSRN [ssrn.com/abstract=3198093](https://ssrn.com/abstract=3198093) or <http://dx.doi.org/10.2139/ssrn.3198093>

<sup>33</sup> Cevik S, Jalles J (2020) This Changes Everything: Climate Shocks and Sovereign Bonds. In: IMF Working Paper No. 20/79. International Monetary Fund, Washington, DC

<sup>34</sup> Cevik, S and Jalles, JT (eds) (2020) An Apocalypse Foretold: Climate Shocks and Sovereign Defaults. IMF Working Paper 2020/231.

Available at [imf.org/en/Publications/WP/Issues/2020/11/08/An-Apocalypse-Foretold-Climate-Shocks-and-Sovereign-Defaults-49784](https://imf.org/en/Publications/WP/Issues/2020/11/08/An-Apocalypse-Foretold-Climate-Shocks-and-Sovereign-Defaults-49784)

<sup>35</sup> Cevik, S and Jalles, JT (eds) (2020) An Apocalypse Foretold: Climate Shocks and Sovereign Defaults. IMF Working Paper 2020/231.

Available at [imf.org/en/Publications/WP/Issues/2020/11/08/An-Apocalypse-Foretold-Climate-Shocks-and-Sovereign-Defaults-49784](https://imf.org/en/Publications/WP/Issues/2020/11/08/An-Apocalypse-Foretold-Climate-Shocks-and-Sovereign-Defaults-49784)

<sup>36</sup> ICE Sustainable Finance also incorporates a principal components methodology



## Grenada & Barbados: case studies in the dual challenges of debt sustainability and climate adaptation

The ICE Sustainable Finance climate and default risk models establish a relationship between climate risk and sovereign default risk (Figure 3). Yet, from a certain perspective, this link can seem somewhat abstract: it is an average association across the 196 countries in the analysis. A better understanding of the real-world implications of these results can be gained from studying the debt sustainability challenges faced by two individual at-risk countries in the Caribbean, Barbados and Grenada, over the last few decades.

In September 2004, Hurricane Ivan resulted in the destruction or severe damage of over 90% of houses on the island of Grenada. Total damage amounted to more than 200% of nominal GDP.<sup>37</sup> The hurricane had direct implications for the country's position in the sovereign bond market; in its aftermath, S&P downgraded the island's credit rating from 'B+' with a stable outlook to 'B-' with a negative outlook due to the damage.<sup>38</sup> The country was soon forced to restructure its debt obligations.<sup>39</sup>

A decade later, during a second restructuring in 2015, Grenada became the first country to advocate for the addition of a natural disaster clause to sovereign bonds, a clause that "embeds within the contractual terms of a debt instrument the ability of an issuer to defer payments of interest and principal in the event of a qualifying natural disaster."<sup>40</sup> The clause allows Grenada to defer principal and interest payments if it experiences a tropical cyclone that results in over US\$15 million in losses, with different increasing monetary thresholds indicating how many payments will be deferred. The Caribbean Catastrophic Risk Insurance Facility (CCRIF) determines the dollar amount of the loss experienced.<sup>41</sup>

Between 2018 and 2019, Barbados followed Grenada in pushing for the implementation of a disaster clause for its own debt. Barbados' clause took years to negotiate, but the final agreement covered almost all the country's debt stock and incorporated both tropical cyclones and earthquakes as trigger events. Despite successful implementation of the clause, Barbados's fiscal and debt-related challenges were far from over. In 2017, Barbados had been spending 55% of its annual GDP servicing its debt and less than 5% on programs related to health care and the environment. The government had sought support from the International Monetary Fund (IMF) and in return, Barbados agreed to produce an annual surplus of 6% of its GDP. By 2020, coupled with the negative financial impacts of the COVID19 pandemic on the country's tourism industry, this commitment created a strain on Barbados' budget.<sup>42,43</sup> Additionally, in July 2021, Barbados was struck by Hurricane Elsa, the first hurricane to hit the island since 1955.<sup>44</sup> Although damage from the hurricane did not reach the necessary level to trigger the natural disaster clause, it still had significant negative impacts.<sup>45</sup>

The complex challenges facing countries like Barbados are not unique to the Caribbean states. Many low-income countries have not historically contributed to the global increase in CO<sub>2</sub> emissions, and yet as a group these countries are disproportionately exposed to physical climate risks. The global mean historical ICE Physical Risk Score is 1.5; across countries identified by the World Bank as low-income,<sup>46</sup> it is 2.1, and across independent countries identified by the World Bank as high-income, it is 0.9. These disparities in physical climate risk persist into the future under all three Shared Socioeconomic Pathways considered by ICE Sustainable Finance (e.g., Figure 4).

<sup>37</sup> Ho, S.-J., & Fontana, S. Sovereign Debt Evolution. (Spring 2021). Cleary Gottlieb Report, Issue No. 11. Accessed Nov. 17, 2021.

Available at [clearygottlieb.com/-/media/files/emri-materials/issue-11-spring-2021/article\\_natural\\_disaster\\_clause\\_v3-pdf](https://clearygottlieb.com/-/media/files/emri-materials/issue-11-spring-2021/article_natural_disaster_clause_v3-pdf)

<sup>38</sup> Taylor, S. (Aug. 14, 2023). Commentary: Hurricanes and the Caribbean Region. First Citizens.

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<sup>39</sup> Ho, S.-J. & Fontana, S. (2021)

<sup>40</sup> Ho, S.-J., & Fontana, S. (2021).

<sup>41</sup> Ho, S.-J., & Fontana, S. (2021).

<sup>42</sup> Anthony, M., Impavido, G., & van Selm, B. (2020, March 18). Barbados' 2018-19 sovereign debt restructuring - a sea change?

SSRN: [papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3555905](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3555905)

<sup>43</sup> Lustgarten, A (Ju 27, 2022). The Barbados Rebellion. The New York Times Magazine.

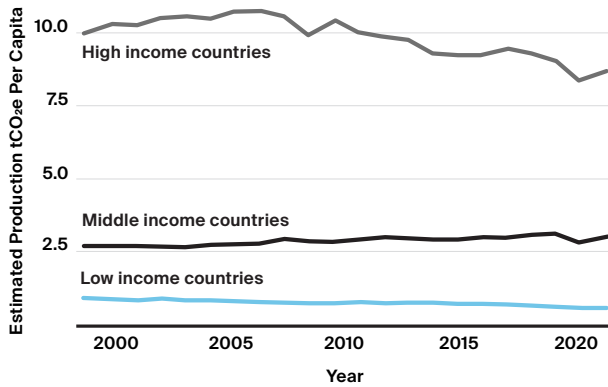
<sup>44</sup> NOAA. (2022, March 14). National Hurricane Center Tropical Cyclone Report: Hurricane Elsa. [nhc.noaa.gov/data/tcr/AL052021\\_Elsa.pdf](https://nhc.noaa.gov/data/tcr/AL052021_Elsa.pdf)

<sup>45</sup> Lustgarten, A (2022)

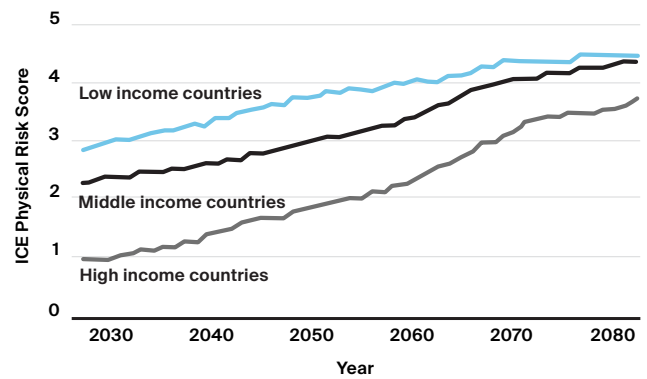
<sup>46</sup> World Bank Country and Lending Groups Country Classifications for the Current 2024 fiscal year. Accessed Nov. 17, 2023.

Available at [datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups](https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups)

## a. Estimated Production tCO<sub>2</sub>e Per Capita



## b. ICE Physical Risk Scores, 2030-2080



**Figure 4:** a) Median estimated production of CO<sub>2</sub> equivalent (in tons per capita) across high-, middle-, and low-income countries from 2000-2021. (The World Bank's "upper middle income" and "lower middle income" classifications are combined into one category.) b) Median ICE Physical Risk Scores projected into the future from 2030 to 2080 for these same groups of countries under the very high emissions pathway SSP5-8.5.

**Source:** ICE Sustainable Finance as of 11/02/2023

The IMF's Debt Sustainability Analysis for Poverty Reduction and Growth Trust (PRGT)-eligible countries (IMF DSA for PRGT-eligible countries) identifies over 60 countries that are either in debt distress or at moderate or high risk of debt distress as of August 31, 2023.<sup>47</sup> Over 60% of these countries have historic ICE Physical Risk Scores greater than 2; by 2050, under a very high emissions scenario (SSP5-8.5), this percentage is projected to increase to over 80%. Many of these countries are caught in a debt-climate trap: while climate adaptation likely reduces the impacts of climate-related events,<sup>48</sup> the upfront investment required for adaptation projects comes at a high cost for low-income debtor countries – costs that may only increase if the country experiences a climate shock.<sup>49</sup> Borrowing costs may rise for other reasons as well; under a very high emissions scenario, one study estimates that more than 60 sovereigns may experience downgrades because of climate change.<sup>50</sup>

ICE Sustainable Finance highlights several ideas that could help vulnerable countries, communities, and individuals around the world fund adaptation efforts and make international financial markets—the markets that tie all of us together – more resilient to climate change.

<sup>47</sup> The International Monetary Fund's List of Low Income Country Debt Sustainability Analyses for Poverty Reduction and Growth Trust Eligible Countries (LIC DSAs for PRGT-Eligible Countries as of Aug. 31, 2023). Accessed Nov. 17, 2023. Available at [imf.org/external/pubs/ft/dsa/dsalist.pdf](https://imf.org/external/pubs/ft/dsa/dsalist.pdf), PDF linked to from [imf.org/en/Publications/DSA](https://imf.org/en/Publications/DSA)

<sup>48</sup> Bakkensen, LA & R Mendelsohn (2016). Risk and Adaptation: Evidence from Global Hurricane Damages and Fatalities. *Journal of the Association of Environmental and Resource Economists* 3(3). <https://doi.org/10.1086/685908>. Available at [laurabakkensen.com/wp-content/uploads/2016/01/Risk-and-Adaptation.pdf](https://www.laurabakkensen.com/wp-content/uploads/2016/01/Risk-and-Adaptation.pdf)

<sup>49</sup> Kraemer, M. M. Mrsnik, A. Petrov, & B.S. Glass. 2015. Storm Alert: Natural Disasters Can Damage Sovereign Credit Worthiness. S&P Global Ratings. Accessed Sept. 9, 2023.

<sup>50</sup> Klusak, P, Agarwala, M, Burke, M, Kraemer, M, K Mohaddes (2023). Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness. *Management Science* 0(0). [doi.org/10.1287/mnsc.2023.4869](https://doi.org/10.1287/mnsc.2023.4869)



## What market stakeholders can do

**Credit rating agencies.** Over the past few decades, credit rating agencies have been subjected to criticism from regulators, policymakers, and the media. These agencies have been accused of issuing ratings that are unfair<sup>51, 52, 53, 54</sup> contributing to the 2008 financial crisis with flawed and inflated ratings of risky securities,<sup>55</sup> and exacerbating the Eurozone crisis in 2010.<sup>56</sup> For countries already struggling with the impacts of climate change, the increased cost of borrowing caused by a ratings downgrade can potentially create a downward spiral dynamic. Grenada's downgrade in the aftermath of Hurricane Ivan, for example, hurt the country's ability to secure favorable financing terms when funding for recovery and reconstruction efforts were needed.<sup>57</sup> Yet, credit ratings are fundamental to international markets – some argue that they are so fundamental as to constitute a “common language,” a shared risk framework that enables financial transactions, negotiations, and regulation and policy development across the world.<sup>58</sup> Going forward, to further the United Nations Sustainable Development Goals, the United Nations Department of Economic and Social Affairs has proposed that ratings agencies increase the transparency of their methodologies and develop long-term ratings to help countries issue debt with long maturities.<sup>59</sup> Enhanced transparency could have many benefits, including allowing governments in developing countries to see a clearer path towards upgrades and addressing accusations of unfairness. Initiatives like those of the African Union to launch its own credit ratings agency<sup>60</sup> could exert pressure in these directions.

**Investors and asset managers.** Increased demand for bonds issued by climate-vulnerable countries could help governments decrease borrowing costs. For some investors and asset managers, this sort of shift might require more independent research into the conditions in specific countries and/or significant changes to investment policies (in terms of minimum ratings, etc.). The development of an index that tracks bonds issued by climate-vulnerable countries – including bonds that incorporate natural disaster clauses – could further facilitate this approach. Going forward, regulators and policymakers could also incorporate investments in climate-vulnerable countries into regulatory frameworks, just as they might carbon offsets or carbon credits.

**The Bridgetown Initiative.** In 2022, Prime Minister Mia Mottley of Barbados spearheaded the development of the Bridgetown Initiative, a set of action items to reform the global financial system and mobilize more concessional finance for climate-vulnerable countries. The ideas of the initiative have included liquidity support for vulnerable countries via unused Special Drawing Rights of the International Monetary Fund; incentivize private investment in climate mitigation and adaptation in developing countries; the inclusion of natural disaster clauses in sovereign debt issuance; streamlining and incorporating incentives for climate adaptation in debt restructuring negotiations; and governance changes to international financial institutions that would incorporate more perspectives and leadership input from countries in the Global South.<sup>61, 62</sup> The IMF and the World Bank have been broadly receptive to these ideas; as of June 2023, \$100B in Special Drawing Rights have been made available to vulnerable countries<sup>63</sup> and the World Bank announced it will allow debt service payment suspensions for developing countries affected by natural disasters.<sup>64</sup> However, from the perspective of supporters of the initiative, there is much more to be done.

<sup>51</sup> George, L. (Sept. 12, 2023). African Union plans to launch its own credit ratings agency. Reuters. Available at [reuters.com/world/africa/african-union-plans-launch-its-own-credit-ratings-agency-2023-09-12/#:~:text=The%20AU%2C%20and%20leaders%20of,as%20the%20COVID-19%20pandemic](https://www.reuters.com/world/africa/african-union-plans-launch-its-own-credit-ratings-agency-2023-09-12/#:~:text=The%20AU%2C%20and%20leaders%20of,as%20the%20COVID-19%20pandemic)

<sup>52</sup> Barta, Z & A Johnston (2017). Rating politics? Partisan Discrimination in Credit Ratings in Developed Economies, *Comparative Political Studies*, 51(5), 587-620.

<sup>53</sup> Outlook Business Desk (Jun. 12, 2023). Are Sovereign Credit Ratings Biased? Here's why India is asking for a credit rating upgrade. Outlook India: Business and Money, Available at [business.outlookindia.com/news/are-sovereign-credit-ratings-biased-here-is-why-india-is-asking-for-a-credit-rating-upgrade-news-295958](https://business.outlookindia.com/news/are-sovereign-credit-ratings-biased-here-is-why-india-is-asking-for-a-credit-rating-upgrade-news-295958)

<sup>54</sup> African Sovereign Credit Rating Review (2023). African Peer Review Mechanism. United Nations Economic Commission for Africa. Report No. G&SR-CRA05/2023, Available at [repository.uneca.org/bitstream/handle/10855/49850/b12035440.pdf?sequence=1&isAllowed=y](https://repository.uneca.org/bitstream/handle/10855/49850/b12035440.pdf?sequence=1&isAllowed=y)

<sup>55</sup> Reuters (Jan. 14, 2017). Moody's \$864m penalty for ratings in run-up to 2008 financial crisis. The Guardian.

Available at [theguardian.com/business/2017/jan/14/moodys-864m-penalty-for-ratings-in-run-up-to-2008-financial-crisis](https://www.theguardian.com/business/2017/jan/14/moodys-864m-penalty-for-ratings-in-run-up-to-2008-financial-crisis)

<sup>56</sup> Waterfield, B. (Apr. 28, 2010). European Commission's angry warning to credit rating agencies as debt crisis deepens. The Telegraph.

Available at [telegraph.co.uk/news/worldnews/europe/greece/7646434/European-Commissions-angry-warning-to-credit-rating-agencies-as-debt-crisis-deepens.html](https://www.telegraph.co.uk/news/worldnews/europe/greece/7646434/European-Commissions-angry-warning-to-credit-rating-agencies-as-debt-crisis-deepens.html)

<sup>57</sup> Taylor, S. (Aug. 14, 2023). Hurricanes and the Caribbean Region. First Citizens. [firstcitizensgroup.com/tt/news-insights/hurricanes-and-the-caribbean-region](https://www.firstcitizensgroup.com/tt/news-insights/hurricanes-and-the-caribbean-region)

<sup>58</sup> Barta, Z. (Aug. 13, 2022). Rating Sovereigns: Sovereign ratings in a financialized world. Phenomenal World.

Available at [phenomenalworld.org/analysis/sovereign-ratings/](https://phenomenalworld.org/analysis/sovereign-ratings/)

<sup>59</sup> United Nations Department of Economic and Social Affairs Policy Brief No. 131 (Mar. 21, 2022). Credit rating agencies and sovereign debt: Four proposals to support the achievement of the SDGs. Available at

[un.org/development/desa/dpad/publication/un-desa-policy-brief-no-131-credit-rating-agencies-and-sovereign-debt-four-proposals-to-support-achievement-of-the-sdgs](https://un.org/development/desa/dpad/publication/un-desa-policy-brief-no-131-credit-rating-agencies-and-sovereign-debt-four-proposals-to-support-achievement-of-the-sdgs)

<sup>60</sup> George, L. (Sep. 12, 2023). African Union plans to launch its own credit ratings agency. Reuters. Available at [reuters.com/world/africa/african-union-plans-launch-its-own-credit-ratings-agency-2023-09-12/#:~:text=The%20AU%2C%20and%20leaders%20of,as%20the%20COVID-19%20pandemic](https://www.reuters.com/world/africa/african-union-plans-launch-its-own-credit-ratings-agency-2023-09-12/#:~:text=The%20AU%2C%20and%20leaders%20of,as%20the%20COVID-19%20pandemic)

<sup>61</sup> Reuters (Jun. 20, 2023). Explainer: What is the 'Bridgetown Initiative' asking for at Paris Financial summit?

Available at [reuters.com/business/finance/what-is-bridgetown-initiative-asking-paris-financial-summit-2023-06-20](https://www.reuters.com/business/finance/what-is-bridgetown-initiative-asking-paris-financial-summit-2023-06-20)

<sup>62</sup> Persaud, A. (Accessed Oct. 23, 2023). Breaking the deadlock on Climate: The Bridgetown Initiative. After COP 27: Geopolitics of the Green deal, Issue #3. Group d'Etudes Geopolitiques, Available at [geopolitique.eu/en/articles/breaking-the-deadlock-on-climate-the-bridgetown-initiative](https://geopolitique.eu/en/articles/breaking-the-deadlock-on-climate-the-bridgetown-initiative)

<sup>63</sup> Reuters Staff (Jun. 22, 2023). IMF has hit \$100 billion target of special drawing rights for vulnerable countries, Georgieva says.

Available at [reuters.com/markets/imf-has-hit-100-bln-target-sdrs-vulnerable-countries-georgieva-2023-06-22/](https://www.reuters.com/markets/imf-has-hit-100-bln-target-sdrs-vulnerable-countries-georgieva-2023-06-22/)

<sup>64</sup> Harvey, F. (Jun. 22, 2023). World Bank offer developing countries debt pauses if hit by climate crisis. The Guardian.

[theguardian.com/environment/2023/jun/22/world-bank-offers-developing-countries-debt-pauses-if-hit-by-climate-crisis](https://www.theguardian.com/environment/2023/jun/22/world-bank-offers-developing-countries-debt-pauses-if-hit-by-climate-crisis)



**Climate reparations.** Some scholars argue that climate reparations are the only way to address the harm caused by climate change both within the United States<sup>65</sup> and internationally.<sup>66</sup> The historic loss and damage fund<sup>67</sup> agreement adopted at COP27 in 2022 was a significant step in this direction,<sup>68</sup> though contributions to the fund are not mandatory.<sup>69</sup>

**Debt-for-adaptation swaps.** Several high-profile debt-for-nature swaps over the last few years have led some to raise the possibility of “debt-for-adaptation” swaps.<sup>70</sup> Debt-for-nature swaps are well-established (if complex) transactions in which countries receive debt relief in terms of reduced principal and interest payments via debt buy backs and credit enhancement in return for committing to specific conservation targets. Under the U.S. Tropical Forest Conservation Act,<sup>71</sup> the U.S. government has conducted many of these swaps on a bilateral basis with debtor nations, but the scale of these swaps has increased over the last decade. The Seychelles received a write-off of \$22 million of its debt with the help of The Nature Conservancy in 2015, in return for committing to designate 30% of its marine territory as protected; Barbados, Belize, and Ecuador have recently completed larger swaps.<sup>72</sup> Though scalability is a challenge given the complicated nature of these swaps, the passage of a “U.S. Climate Adaptation Act” analogous to the Tropical Forest Conservation Act could kickstart these sorts of transactions and perhaps spur other countries and private creditors to follow. The United States could also play a credit enhancement role as it has for past debt-for-nature swaps. (As the biggest international sovereign creditor, China could have an immense impact). Issues of sovereignty of the debtor nations<sup>73</sup> in these transactions should of course be carefully considered.

**Insurance and catastrophe bonds.** Financial adaptations like catastrophe bonds and disaster insurance—particularly parametric insurance due to its low cost and speed of payouts – can reduce countries’ long-term losses in the wake of natural disasters. One study built and calibrated a model based on the impacts of tropical cyclones in Mexico<sup>74</sup> and suggested that together, catastrophe bonds and disaster insurance may help reduce losses due to climate change by about 25%. Multi-country risk pools such as the Pacific Catastrophe Risk Assessment and Financing Initiative (PCFAFI) can provide limited but quick payouts that can help countries in the immediate aftermath of disasters. The PCFAFI paid out \$1.9 million to the government of Vanuatu, for example, within a week after Tropical Cyclone Pam hit the island nation in 2015 to fund emergency response.<sup>75</sup>

All this said, the capacity of insurance markets to transfer climate-related risks is fundamentally limited – a core principle of insurance is that risks are uncorrelated, but climate change risks are by nature both correlated and increasing over time.<sup>76</sup> Despite the promise of insurance and risk transfer mechanisms to help countries recover and rebuild, they are not a solution. In the future, the main purpose of these financial adaptations may not be to recoup all losses, but instead to provide funds immediately to save lives and mitigate damage.

<sup>65</sup> Donoghoe, M & AM Perry (Mar. 2023). The case for climate reparations in the United States. Brookings.

Available at [brookings.edu/articles/the-case-for-climate-reparations-in-the-united-states](https://brookings.edu/articles/the-case-for-climate-reparations-in-the-united-states)

<sup>66</sup> Plumer, B, Friedman, L & S. Sengupta (Nov. 6, 2022). Developing Nations have a message at Global Climate Talks: Polluters, Pay up. The New York Times, Available at [nytimes.com/2022/11/06/climate/loss-and-damage-climate-cop27.html](https://nytimes.com/2022/11/06/climate/loss-and-damage-climate-cop27.html)

<sup>67</sup> Plumer, B, Friedman, L, Bearak, M, & J Gross (Nov. 19, 2022). In a First, Rich Countries Agree to Pay for Climate Damages in Poor Nations. The New York Times, Available at [nytimes.com/2022/11/19/climate/un-climate-damage-cop27.html](https://nytimes.com/2022/11/19/climate/un-climate-damage-cop27.html)

<sup>68</sup> Gelles, D. (Nov. 8, 2022). After Decades of Resistance, Rich Countries Offer Direct Climate Aid. The New York Times, Available at [nytimes.com/2022/11/08/climate/loss-and-damage-cop27-climate.html](https://nytimes.com/2022/11/08/climate/loss-and-damage-cop27-climate.html)

<sup>69</sup> Moscoff, M (Aug. 28, 2023). Are climate reparations finally on the way for vulnerable countries? Al Jazeera.

Available at [aljazeera.com/news/2023/8/28/are-climate-reparations-finally-on-the-way-for-vulnerable-countries](https://aljazeera.com/news/2023/8/28/are-climate-reparations-finally-on-the-way-for-vulnerable-countries)

<sup>70</sup> Hebbale, C & Urpelainen J (Mar. 21, 2023). Debt-for-adaptation swaps: A financial tool to help climate vulnerable nations. Brookings Report.

Available at [brookings.edu/articles/debt-for-adaptation-swaps-a-financial-tool-to-help-climate-vulnerable-nations](https://brookings.edu/articles/debt-for-adaptation-swaps-a-financial-tool-to-help-climate-vulnerable-nations)

<sup>71</sup> Debt-for-Nature Initiatives and the Tropical Forest Conservation Act (TFCA): Status and Implementation. (Jul. 24, 2018). Congressional Research Service Report RL31286. Available at [crsreports.congress.gov/product/pdf/RL/RL31286/16#:~:text=Under%20this%20program%2C%20debt%20can,buybacks%20to%20generate%20conservation%20funds](https://crsreports.congress.gov/product/pdf/RL/RL31286/16#:~:text=Under%20this%20program%2C%20debt%20can,buybacks%20to%20generate%20conservation%20funds)

<sup>72</sup> Binnie, I. (May 10, 2023). Debt for nature swaps swell in climate finance response. Reuters.

Available at [reuters.com/business/environment/debt-for-nature-swaps-swell-climate-finance-response-2023-05-10](https://reuters.com/business/environment/debt-for-nature-swaps-swell-climate-finance-response-2023-05-10)

<sup>73</sup> Aligiri, P (1992). Give us Sovereignty or Give Us Debt: Debtor Countries’ Perspective on Debt-For-Nature Swaps. American University Law Review 41(2), 485-516

<sup>74</sup> Phan, T & FF Schwartzman, (Mar. 2023). Climate Defaults and Financial Adaptation. Federal Reserve Bank of Richmond Working Paper No. 23-6.

Available at SSRN [ssrn.com/abstract=4437661](https://ssrn.com/abstract=4437661) or <http://dx.doi.org/10.21144/wp23-06>

<sup>75</sup> Sovereign Climate and Disaster Risk Pooling: World Bank Technical Contribution to the G20 (2017). International Bank for Reconstruction and Development, World Bank. Available at [openknowledge.worldbank.org/entities/publication/ef10a5c6-8e7b-539e-9253-96b5958e7cbf](https://openknowledge.worldbank.org/entities/publication/ef10a5c6-8e7b-539e-9253-96b5958e7cbf)

<sup>76</sup> Arun, A (2023). The Doom Loop. Phenomenal World. Available at [phenomenalworld.org/analysis/the-doom-loop](https://phenomenalworld.org/analysis/the-doom-loop)

**Non-governmental and philanthropic organizations.** Non-governmental and philanthropic organizations like The Nature Conservancy and the World Wildlife Fund have historically played an important role in improving the debt sustainability and financial resilience of climate vulnerable countries. These organizations have been involved in helping to arrange both debt-for-nature swaps and insurance policies for coral reefs—financial transactions that also incorporate an element of climate adaptation. Healthy coral reefs physically protect coastlines and support local economies.<sup>77,78</sup> One recent example is the Nature Conservancy’s “Mangrove Insurance Program” proposal for the Bahamas, Florida, and Mexico.<sup>79</sup> These kinds of organizations should continue to use their expertise to find innovative solutions for debt relief and financial resilience that incorporate climate adaptation and mitigation.

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<sup>77</sup> Ocean Facts: How do coral reefs protect lives and property? (Accessed Oct. 23, 2023). The National Oceanic and Atmospheric Administration, Available at [oceanservice.noaa.gov/facts/coral\\_protect.html](https://oceanservice.noaa.gov/facts/coral_protect.html)

<sup>78</sup> Ocean Facts: How do coral reefs benefit the economy? (Accessed Oct. 23, 2023). The National Oceanic and Atmospheric Administration, Available at [oceanservice.noaa.gov/facts/coral\\_economy.html](https://oceanservice.noaa.gov/facts/coral_economy.html)

<sup>79</sup> Clark, A. (Apr. 5, 2023). The Nature Conservancy Identifies Sites for Mangrove Insurance Pilot Projects in the Bahamas, Florida, and Mexico. The Nature Conservancy Newsroom. Available at [nature.org/en-us/newsroom/new-mangrove-insurance-feasibility-report](https://nature.org/en-us/newsroom/new-mangrove-insurance-feasibility-report)

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