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Public Economic Consideration

Do Climate Disasters Increase the Risk of Sovereign Default? Evidence from a Global Panel Analysis



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EXECUTIVE SUMMARY

Climate change presents a serious threat to the fiscal stability of vulnerable economies. Climate-related disasters lead to immediate GDP losses, widen fiscal deficits, and increase public debt, thereby elevating the risk of sovereign default. This paper develops a simple and parsimonious econometric model to assess the relationship between climate disasters and the onset of sovereign default, controlling for key macroeconomic fundamentals such as GDP, liquidity, solvency, and structural climate vulnerability. Our panel dataset of 104 developing and middle-income countries over 2001–2021 shows that climate disasters are significantly correlated with default onsets. Across model specifications, a climate disaster is associated with a 2.2 to 2.5 percentage point increase in default probability. These findings highlight the importance of integrating climate risk into sovereign risk management. They also point to the potential role of scaling up specialised climate-contingent instruments that can provide rapid liquidity after a climate shock, such as Climate Resilient Debt Clauses (CRDCs) and Contingent Emergency Response Components (CERCs).

INTRODUCTION

Climate change has emerged as one of the most profound macroeconomic risks confronting the global economy. Since the late nineteenth century, global surface temperature has risen by approximately 1.1°C (IPCC, 2023). Human activities have increased both the hazard and the intensity of several types of extreme weather events, such as heavy precipitation, regional droughts, tropical cyclone related extremes, and more frequent, longer heatwaves. Recent assessments by the Intergovernmental Panel on Climate Change suggest that, under current policy trajectories, global temperatures could reach around 3.2°C above pre-industrial levels by the end of the century, substantially amplifying the incidence of extreme weather events (IPCC, 2023). These physical climate shocks pose not only long-run growth challenges but also acute macro-financial risks by disrupting production, eroding fiscal space, and weakening debt sustainability.

While the macroeconomic impacts of climate change have been widely documented, particularly its adverse effects on output, productivity, and growth volatility (Dell, Jones, & Olken, 2012; Kahn et al., 2021), far less is known about the implications of climate-related disasters on sovereign default and debt restructuring events. This gap is striking given that developing and middle-income economies now face a combination of high public debt levels, tighter global financial conditions, and increasing exposure to climate hazards.

In recent years, a growing strand of literature has begun to explore the links between higher climate vulnerability and lower resilience, particularly for emerging and low-income countries (Batten et al., 2020; Kling et al., 2025; Cevik & Jalles, 2020a; Beirne, Renzhi, & Volz, 2021). Much of this work focuses on least developed countries (LDCs) and small island developing states (SIDS), where climate shocks are more frequent and generally

assumed to have severe fiscal and financial consequences given limited institutional capacity and constrained fiscal space. However, far less attention has been paid to whether climate shocks are associated with actual sovereign debt defaults outside LDCs and SIDS. Therefore, this paper asks the following research question:

> "Do climate related disasters increase the probability of sovereign default onset in low and middle income countries?"

To address this gap, the paper analyses whether climate disasters increase the probability of sovereign default onset relative to years without climate disasters, using a panel dataset of 104 low and middle income countries over the 2001-2021 period. We define sovereign default as the onset of a missed payment or a debt restructuring classified as a distressed credit event by Horn, Reinhart & Trebesch (2022) and Erce, Mallucci & Picarelli (2022).

In the process of addressing the broad question, this paper makes three key contributions to the existing literature. First, it provides one of the first large sample empirical assessments of whether climate related disasters are associated with higher probabilities of sovereign default and debt restructuring events. Second, it provides a systematic assessment of how climate shocks interact with fiscal stability across low , lower middle , and upper middle income economies, with emphasis on their existing resilience levels for climate shocks. Third, the findings contribute to policy discussions on climate risk and fiscal stability by assessing the role of disaster linked and state contingent debt instruments, which can provide temporary fiscal space after extreme events and reduce the likelihood that climate shocks coincide with sovereign default.

The remainder of the paper is organised as follows. First, we review the related literature on climate change, sovereign risk, and debt distress. We then present the data sources and variable construction, outline the empirical strategy and results, discuss the policy implications, and conclude.

LITERATURE

The Cost of Natural Disasters for Vulnerable Economies

Natural disasters impose large fiscal burdens and reduce sovereign repayment capacity, with disproportionate impacts on small and low-income economies. Cross-country research (Noy, 2009; Hochrainer, 2009) established that disasters produce significant short-run GDP losses, with a proportionally larger effect in small, vulnerable economies, where losses represent a substantial share of productive capital. For small, disaster-prone Caribbean and Pacific states, natural disasters cause damage equivalent to 2-3% of GDP annually (IMF, 2019). Milivojevic (2021) shows that when states borrow externally under stress, rollover risk and debt-service burdens rise, increasing future financing costs, especially when policy responses are large and pre-existing fiscal space is small. Additionally, International Institute for Environment and Development (IIED) analysis shows that climate disasters increase external debt-servicing obligations through higher interest rates and adverse exchange-rate movements, particularly for economies maintaining currency pegs with limited hard-currency reserves (Bharadwaj et al., 2025). However, evidence directly linking climate disasters to sovereign default risk is still limited but growing. Drawing on a sample of 115 countries from 1985 to 2010, Klomp (2017) finds that the onset of a sovereign default is around three percentage points more likely after a major natural disaster. Although this provides broad temporal coverage, there could be a risk that disaster records from earlier years may be less complete,

potentially limiting comparability over time. More recently, Cevik & Jalles (2020a), using the ND-GAIN indicators of climate vulnerability and climate readiness, find that higher vulnerability increases the likelihood of sovereign debt default, while greater readiness reduces it. These studies highlight that disaster related shocks can translate into sovereign distress. However, most existing work focuses either on natural disasters in general, or on structural climate vulnerability, rather than on climate disasters and default events.

Impact of Disasters on Public Debt

Transmission channels through which disasters degrade fiscal balance work both on the expenditure and revenue sides. Emergency government expenditures are required for immediate disaster relief payments, infrastructure reconstruction, social protection of households, and other disaster relief measures (Bachner & Bednar-Friedl, 2019). At the same time, higher temperatures can reduce economic output (Burke et al., 2015), potentially narrowing the tax base on which government revenues depend (Bachner & Bednar-Friedl, 2019). This leaves many governments ill-equipped to deal with rising disaster costs without resorting to expensive external financing (IMF, 2019). Empirical studies show that climate-vulnerable countries face higher debt-servicing costs and greater risk of capital market exclusion, particularly among SIDS, where existing credit-rating methodologies can constrain investment in resilience (Bharadwaj et al., 2024; Kling et al., 2025). Cross-country analysis confirms that both climate vulnerability and resilience significantly affect government borrowing costs (Beirne et al., 2021; Cevik & Jalles, 2020b). Empirical evidence also suggests that extreme weather events can materially deteriorate government budget balances, particularly in developing economies (Lis & Nickel, 2009).

Repayment Capacities, Borrowing Costs, and Disaster Risk Funding

The negative impact of fiscal imbalance from extreme weather events has largely depended on government and donor support (Ghesquiere & Mahul, 2010; UNCTAD, 2025). However, traditional financing instruments are likely to become increasingly inadequate as extreme weather events intensify, and international aid has been declining in recent years and becoming more uncertain (OECD, 2025). Furthermore, traditional insurance struggles when risks become systemic rather than idiosyncratic, leading to unaffordable products, or in some cases a complete lack of coverage (Kousky, 2019), while risk-transfer instruments such as catastrophe bonds represent complex financial instruments. Their penetration remains low, leaving countries with large protection gaps and a slower reconstruction path (Linnerooth-Bayer & Hochrainer-Stigler, 2015). Clarke and Dercon (2016) show that while parametric insurance can provide fast liquidity, poorly designed triggers (e.g., rainfall thresholds or modelled losses) create basis risk, where payouts fail to match actual country needs. Moreover, sovereign disaster-risk pools like Caribbean Catastrophe Risk Insurance Facility (CCRIF) and African Risk Capacity (ARC), although innovative, have limited capitalisation and cannot cover large, multi-country climate events. The International Association of Insurance Supervisors indicates that, as natural catastrophe events become more frequent and intense due to climate change, the insurability and affordability of insurance coverage are increasingly challenged, widening protection gaps (IAIS, 2023). These limitations have prompted greater interest in state contingent sovereign debt instruments that provide automatic fiscal space after severe climate events, including Climate Resilient Debt Clauses (CRDCs) and Contingent Emergency Response Components

(CERCs), which, although primarily risk retention tools, can deliver rapid liquidity to buffer climate shocks (Pina, 2022; World Bank, 2023a, 2023b, 2025a, 2025b).

DATA

Main Variables of Interest: Climate Disasters and Sovereign Default Onset

To address our research question, we develop a parsimonious econometric probability model to isolate the effect of climate disasters on sovereign defaults. Importantly, the analysis extends beyond SIDS and LDCs, typically considered most vulnerable, to include a broader range of developing and middle-income economies. Our analysis centres on two main variables of interest: climate disasters and sovereign default onset.

Climate disaster data comes from the Emergency Events Database (EM-DAT, 2026), a widely used global disaster database developed by the Centre for Research on the Epidemiology of Disasters and the University of Louvain. EM-DAT records events involving either a declared emergency, an international assistance request, at least 10 deaths or at least 100 affected people, establishing a minimum threshold that excludes minor events. Given the cross-country panel setting and the limited comparability of disaster-intensity measures, we define climate disasters using a binary indicator, drawing on the wider cross-country disaster literature (Ramcharan, 2005; Noy, 2009; Klomp, 2017). Although intensity measures (e.g., damages/GDP) would be preferable, they are incomplete and inconsistently reported, which would substantially reduce our sample coverage. Therefore, using a binary variable helps us prioritise comparability and coverage.

Consistent with the definition in the Introduction, we define sovereign default as a binary indicator equal to 1 in the year a new default onset occurs. We combine Horn et al. (2022), covering private-creditor, Paris Club and Chinese-lender restructurings, with Erce et al. (2022), covering domestic-law public-debt defaults and restructurings. This combined dataset additionally allows us to capture default events involving Chinese lending to developing countries, which have received limited coverage in previous sovereign-debt analyses. Our preferred definition excludes symbolic debt-relief events and suspensions under the Debt Service Suspension Initiative (DSSI). DSSI suspensions are excluded because they were pandemic-related payment deferrals rather than conventional defaults arising from sovereign credit distress (World Bank, 2022). However, a key limitation is that debt crisis start and end dates can be imprecise, with crises often persisting across years and creating endogeneity. To address this, we follow Klomp (2017) by focusing only on the onset of defaults. This means the dependent variable records a new onset only after at least two consecutive years without a recorded default or restructuring event.[1]

Our sample covers 104 countries from 2001 to 2021, focusing on low-, lower-middle-, and upper-middle-income countries as classified by the World Bank (World Bank, 2024). We chose this 21-year period for two reasons. First, as the Emergency Events Database (EM-DAT) notes, only disaster data from 2000 onwards is relatively complete and comparable, and the number of events recorded before 2000 is likely to be underestimated, risking systematic reporting bias in earlier periods. Second, the key variables used in our model, including sovereign debt defaults, the Debt-to-Gross National Income (GNI) ratio, and the ND-GAIN vulnerability index, provide consistent coverage from the early 2000s through to 2021.

1. For example, if Country X experiences a default in 2005 followed by several years of restructuring activity, only the initial event is treated as a new onset. A new onset is recorded only after at least two consecutive years without a recorded default or restructuring event.

TABLE 1: SUMMARY OF VARIABLES AND DATA SOURCES

Variable(s)	Coverage	Dataset / Source	Notes
Sovereign default onset	Global, 2001–2021	Horn, Reinhart & Trebesch (2022), Erce, Mallucci & Picarelli (2022)	Onset of a missed payment or debt restructuring, excluding DSSI and symbolic debt restructurings; Dummy variable
Climate disaster indicator	Global, 2001–2021	Emergency Events Database (EM-DAT) (2026)	Climate events only (Climatological, Meteorological, Hydrological); Dummy variable
Climate vulnerability index	104 countries, 2001–2021	ND-GAIN Country Index (2026)	Measures exposure, sensitivity, and adaptive capacity; Log-transformed
Climate readiness index	104 countries, 2001–2021	ND-GAIN Country Index (2026)	Log-transformed; reflects institutional capacity and policy preparedness
External debt / GNI (%)	104 countries, 2001–2021	World Bank WDI (2026)	Solvency proxy; log-transformed
Debt service / Exports (%)	104 countries, 2001–2021	World Bank WDI (2026)	Liquidity proxy; log-transformed
Real GDP at PPP (constant 2021 international $)	104 countries, 2001–2021	World Bank WDI (2026)	Economic size proxy; log-transformed
Income group	104 countries, 2001–2021	World Bank (2024)	Categorical variable; low income = base category

Control Variables

The ND-GAIN vulnerability and readiness indices help us control for structural differences across countries and their exposure to climate-related shocks. In particular, the vulnerability index captures exposure, sensitivity, and adaptive capacity across six sectors, while the readiness index reflects economic, governance, and social readiness. Together, these measures help account for broader country level differences that may otherwise be captured by omitted variables such as weak institutions or low resilience. While they clearly do not eliminate endogeneity concerns, they represent a significant effort to mitigate them.

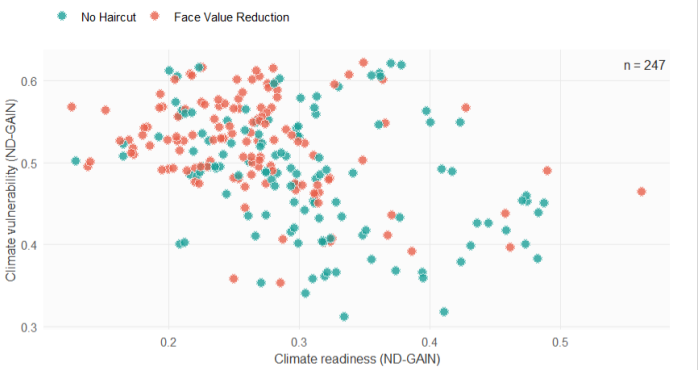
External debt relative to Gross National Income (GNI) is a key indicator of solvency risk, as a higher debt burden compared to national income suggests greater difficulty in meeting repayment obligations. Debt service as a percentage of exports measures liquidity constraints, meaning countries with substantial repayment obligations relative to their export earnings will face more significant external financing pressures, particularly during an exogenous shock such as a climate disaster. Real GDP adjusted for Purchasing Power Parity (PPP) accounts for the economic size and capacity to absorb shocks, as larger economies generally possess greater fiscal resilience. Income group categorisation addresses systematic variations among low-income, lower-middle-income, and upper-middle-income countries, with low-income countries serving as the baseline reference point. World Bank income classification varies over time as countries cross income-per-capita thresholds, allowing it to be estimated separately from country fixed effects in the two-way fixed-effects model.

To our knowledge, this is the first study with this specification that focuses specifically on climate disasters and onset of default, except for Klomp (2017) who examined a different period (1985–2010) and included all types of natural disasters (e.g.

earthquakes), not climate-related events alone. Our model extends prior research in several ways. First, we constructed a new, integrated database combining defaults and debt restructuring events. Second, whereas previous econometric studies often focus on natural disasters broadly or use climate vulnerability indices to assess impacts on defaults, we focus specifically on climate disasters, using data from the EM-DAT global database. Finally, concentrating on the onset of crises reduces endogeneity bias compared to models that treat default as a persistent state.

Additionally, we examined the relationship between climate vulnerability, readiness, and defaults (this time focusing only on country-years in which a default event occurred). Figure 1 plots readiness against vulnerability for these observations. Default events are concentrated among countries combining high vulnerability with low readiness. We were also able to analyse haircuts, i.e., when creditors accept a reduction in the net present value of the debt. Interestingly, higher climate readiness is not only associated with fewer defaults, consistent with the findings of Cevik & Jalles (2020a), but also appears to be associated with a lower incidence of haircuts (represented by the red dots). This suggests that improving climate readiness and reducing climate vulnerability may be in the interest of both sovereign borrowers and investors.

FIGURE 1 - READINESS VS VULNERABILITY IN DEFAULT YEARS (2001-2021)



Authors' calculations based on ND-GAIN, Horn et al. (2022), and Erce et al. (2022).
Note: Axes are truncated and do not start at zero to improve visibility.

EMPIRICAL STRATEGY

The main model: Linear Probability Model (LPM)

The main model is a parsimonious linear probability model (LPM), which provides directly interpretable marginal effects and is therefore useful for policy analysis. Its main limitation is that, as an ordinary least squares model, it can predict values outside the 0–1 range. However, an additional advantage of the LPM is that it retains countries with no within country variation in default onsets (e.g., countries with no defaults in the sample). This is particularly relevant because defaults tend to be rare events. We tested specifications using both two-way fixed effects (1) and random effects (2), applying a cluster-robust Mundlak test to assess whether the random-effects estimator can be treated as consistent. Because the test rejects the null of no correlation between the country effects and the regressors at the 5% level, we lead with the two-way fixed-effects LPM as our main specification and report random effects as a robustness check. To further assess robustness, we also estimated the same

specification using two additional econometric logit methods as nonlinear robustness checks: a mixed-effects model and generalised estimating equations (GEE). Both approaches retain the full country sample and do not impose the mechanical sample restriction of conditional fixed effects logit. Mixed-effects logit (3) models unobserved heterogeneity via random intercepts (potentially improving efficiency), while GEE (4) estimates population average effects with inference robust to within country correlation misspecification. The baseline panel-data specification can be written as follows:

$$\begin{aligned} D_{O,it} = {} & \beta_0 + \beta_1 Climate_Disaster_{it} + \beta_2 \log(Debt/GNI)_{it-1} \\ & + \beta_3 \log(Debt\ Service/Exports)_{it-1} + \beta_4 \log(ND\ Vulnerability)_{it-1} \\ & + \beta_5 \log(ND\ Readiness)_{it-1} + \beta_6 \log(GDP_PPP)_{it-1} \\ & + \beta_7 Income_Group_i + \gamma_i + \delta_t + \epsilon_{it} \end{aligned}$$

Where:

- $D_{O,it}$: Binary variable indicating the onset of sovereign default in country *i* at year *t* (1 if onset, 0 otherwise).
- $Climate_Disaster_{it}$: Binary variable indicating whether country *i* experienced at least one climate-related disaster as defined by the EM-DAT in year *t*.
- $log\left(\frac{Debt}{GNI}\right)_{it-1}$: Natural log of the lagged ratio of total external debt to gross national income, proxying insolvency risk.
- $log\left(\frac{Debt\ Service}{Export}\right)_{it-1}$: Natural log of the lagged ratio of total debt service to exports of goods and services, measuring external liquidity pressure.
- $log(ND_Vulnerability)_{it-1}$:Log of the lagged ND-GAIN climate vulnerability index.
- $log(ND_Readiness)_{it-1}$:Log of the lagged ND-GAIN readiness index, reflecting capacity to adapt.
- $log(GDP_{PPP})_{it-1}$:Log of lagged real GDP at purchasing power parity, indicating economic size and ability to absorb shocks.
- $Income\ Group_{it}$: Dummy variables indicating whether country i is classified as lower-middle-income (LMI) or upper-middle-income (UMI) in year t, based on World Bank income classifications, with low-income countries as the reference category.
- γ_i: Country fixed effects to control for unobserved, time-invariant heterogeneity across countries (in the FE LPM specification only).
- δ_t: Year fixed effects to control for common shocks affecting all countries (in the FE LPM specification only).
- ε_{it}: Idiosyncratic error term.

The model focuses on the discrete onset of default to minimise endogeneity and uses lagged control variables to avoid reverse causation. This allows us to estimate the impact of climate disasters on sovereign debt default among a large sample of countries, while controlling for key macroeconomic factors.

Main Result

The main finding from the models is that climate disaster shocks increase the probability of sovereign default onset by 2.2 to 2.5 percentage points across specifications, significant at the 5% level or better (Table 2). While seemingly modest, this is a meaningful rise given the rarity of default events: the unconditional onset rate in our sample is approximately 5% of country-years, so the estimated effect represents a proportionally large increase in risk. The 95% confidence intervals span roughly 0.2 to 4.8 percentage points across specifications. Although the estimates are statistically significant in all specifications, wide standard errors reflect considerable uncertainty about the magnitude of the effect.

TABLE 2: AVERAGE MARGINAL EFFECTS (AME) OF CLIMATE DISASTERS ON DEFAULT PROBABILITY

Model	Model Specification	AME (pp)	Std. Error
(1)	Fixed Effects (LPM, two-way, DK SEs)	2.47**	1.18
(2)	Random Effects (LPM, DK SEs)	2.15***	0.80
(3)	Mixed-Effects (Logit)	2.31**	0.98
(4)	GEE (Logit)	2.32***	0.76

AME = Average Marginal Effect, expressed in percentage points. Driscoll–Kraay standard errors with a maximum lag of 2 are used for the LPM specifications, while robust standard errors are used for the logit specifications. For the logit models, AMEs are calculated by averaging the marginal effects across all observations. Statistical significance is indicated as follows: *** p < 0.01, ** p < 0.05, * p < 0.10.

Control Variables

Control variables behave consistently across specifications (Table 3). Unsurprisingly, external debt as a percentage of GNI (a proxy for solvency) and debt service as a percentage of exports (a proxy for liquidity) significantly increase default risk in every model. Coefficients on log(Debt/GNI) are significant at the 1% level throughout, and log(Debt Service/Exports) behaves similarly. Climate readiness is significantly associated with lower default risk across all four specifications, reflecting institutional capacity, policy preparedness, and adaptive capability, though the effect is weaker (significant only at the 10% level) under fixed effects. The ND-GAIN vulnerability index carries the expected positive sign in all four models, though it remains insignificant under the mixed-effects logit and GEE specifications. Larger economies, measured by GDP in PPP terms, exhibit lower default probabilities in the random-effects LPM and both logit specifications, although the relationship is not statistically significant in the fixed-effects model. Income-group indicators are not statistically significant, suggesting that even after controlling for income levels, climate disasters remain relevant predictors of sovereign default.

Robustness Checks

We treat the two-way fixed-effects LPM as the baseline specification. The Mundlak test rejects the null hypothesis that the country-specific effects are uncorrelated with the regressors. This is not particularly surprising in a cross-country panel, where unobserved country characteristics are likely to affect sovereign default risk. The random effects LPM, mixed effects logit, and GEE logit serve as robustness checks. The results across all four models demonstrate remarkable consistency for our variable of interest, including in the fixed effects specification. Under fixed effects, some control variables lose statistical significance. This is expected: fixed effects rely solely on within country deviations from the country mean, leaving limited usable variation for slow moving controls but sufficient variation for climate related shocks. The random effects and GEE models are more efficient in principle, since they exploit variation both within and across countries, but they rely on the stronger assumption that the country effects are uncorrelated with the regressors. As an additional robustness check, the Annex re-estimates all specifications excluding the COVID-19 period (2020-2021). The estimated effect of climate disasters remains stable and statistically significant, suggesting that the main findings are not driven by pandemic-related shocks.

Summary of Model Results

Our analysis shows that our variable of interest, Climate Disaster, has a marginal effect in the 2.2–2.5 percentage point range across all specifications. This effect is robust across multiple

model specifications and controls, highlighting how climate shocks significantly increase the probability of sovereign default onsets. This seems consistent with previous studies; for instance, Klomp (2017), using a panel of 115 countries from 1985–2010, finds that natural disasters, including earthquakes and other geophysical events, increase the likelihood of the onset of a debt crisis by roughly 3 percentage points. These results can support the case for increasing adaptation and disaster preparedness by developing climate-contingent debt instruments and disaster clauses beyond small and vulnerable states to a broader set of developing and middle-income countries, to provide timely and pre-agreed debt relief in response to climate-related events.

TABLE 3: COMPARISON OF MODEL RESULTS ACROSS SPECIFICATIONS

Variable	(1) Fixed Effects (LPM, two-way, DK SEs)	(2) Random Effects (LPM, DK SEs)	(3) Mixed-Effects (Logit)	(4) GEE (Logit)
Climate Disaster	0.0247 ** (0.0118)	0.0215 *** (0.0080)	0.6383 ** (0.2825)	0.6224 *** (0.2121)
log(Debt/GNI)	0.0566 *** (0.0103)	0.0285 *** (0.0070)	0.7180 *** (0.2001)	0.7033 *** (0.1779)
log(Debt Service/ Exports)	0.0278 *** (0.0087)	0.0174 *** (0.0053)	0.5822 *** (0.1412)	0.5786 *** (0.1360)
log(ND Vulnerability)	0.3831 ** (0.1826)	0.0576 * (0.0349)	0.9977 (1.0722)	1.0035 (1.0877)
log(ND Readiness)	-0.0735 * (0.0396)	-0.0462 ** (0.0195)	-1.4432 ** (0.5646)	-1.4106 *** (0.4632)
log(GDP PPP)	0.0122 (0.0169)	-0.0045 ** (0.0022)	-0.1702 ** (0.0780)	-0.1649 ** (0.0830)
Income Group (LMI)	-0.0080 (0.0178)	-0.0090 (0.0138)	0.0047 (0.2984)	-0.0111 (0.2930)
Income Group (UMI)	-0.0074 (0.0263)	0.0008 (0.0157)	0.1530 (0.4073)	0.1112 (0.4236)
Observations	1966	1966	1966	1966
Countries	104	104	104	104
R-squared (or adj.)	0.0271	0.0372	–	–

Statistical significance is denoted by *** p < 0.01, ** p < 0.05, and * p < 0.10. Standard errors are reported in parentheses. For the fixed-effects and random-effects models, Driscoll-Kraay standard errors (lag length 2) are used, following Hoechle (2007), to account for serial correlation and cross-sectional dependence. The cluster-robust Mundlak test rejects the random-effects specification at the 5% level; accordingly, the two-way fixed-effects model is used as the baseline specification. The fixed-effects model includes country and year fixed effects. Logit coefficients are reported in log-odds form; average marginal effects are reported separately in Table 2. The R-squared values tend to be less informative in linear probability models and, where available, are reported solely for transparency.

Policy Implications

Our results indicate that climate disasters are not only humanitarian shocks but also macro financial shocks, which can increase the risk of sovereign default onset. This suggests two important policy implications.

- First, climate adaptation and climate disaster financing should be treated as part of sovereign risk management rather than a standalone development tool. In practice, where possible, prepare ex-ante instruments and keep fiscal buffers so a climate shock is less likely to lead to a debt crisis.

- Second, developing and middle income countries, beyond LDCs and SIDS, should design and extend disaster risk financing to protect their fiscal space after a shock. This supports a risk layering approach that combines budget buffers with rapid access contingency finance, allowing governments to respond quickly without costly emergency borrowing.

This raises the practical question of how such an approach would work in practice. Although a comprehensive set of risk-based disaster financing instruments is crucial, the optimal mix will differ across economies, reflecting differences in geographic, macro-financial vulnerabilities, and the costs of accessing and deploying these tools. As climate disasters are becoming more frequent and damaging, countries may need to look beyond traditional instruments such as insurance and catastrophe bonds. Scaling up disaster risk financing implies greater use of middle tier instruments, including contingency credit instruments such as Contingent Emergency Response Components (CERCs) and Climate Resilient Debt Clauses (CRDCs). These represent the "low-hanging fruit" of fiscal resilience to climate shocks. While not a silver bullet and primarily serving as risk retention mechanisms as opposed to new financing, these instruments serve as ex-ante buffers: pre-arranged agreements that provide timely liquidity at relatively low cost, to address the initial phase of a climate disaster, helping countries avoid falling into a debt spiral.

For example, Grenada's experience with CRDCs following Hurricane Beryl in 2024 illustrates the potential value of these instruments. Grenada and St Vincent and the Grenadines became the first countries to activate debt-pause clauses following a natural disaster (Centre for Disaster Protection, 2025). Grenada activated the disaster clause in its restructured international bond, deferring approximately $12 million in scheduled payments, equivalent to 0.9% of GDP (IMF, 2025). In addition, Grenada reportedly deferred roughly a further $5 million under a bilateral loan from Taiwan.[2] The loan included a hurricane clause, an early form of CRDC. Crucially, when combined with CCRIF payouts (CCRIF SPC, 2024) and World Bank concessional funding, the IMF found that Hurricane Beryl's impact on Grenada's debt sustainability remained modest. Similarly, CERCs provided approximately $29 million for early recovery following floods and landslides in Myanmar, and $12.1 million to restore livelihoods, agricultural production, and water infrastructure following floods and drought in southern Madagascar (World Bank, 2025b). To date, instruments like CRDCs and CERCs remain nascent and mostly untested at the global scale. While it is important to stress that CRDCs and CERCs do not replace sound fiscal discipline and debt management, their relatively low cost makes a compelling case for broader adoption.

2. The reported $5 million also included payments on two smaller loans (Jones, 2024).

CONCLUSION

This study asks whether climate disasters are associated with an increased likelihood of sovereign default onsets. Using a panel of 104 low-, lower-middle-, and upper-middle-income countries over 2001–2021, we find that a climate disaster year is associated with a 2.2–2.5 percentage point higher probability of default onset across specifications. The results suggest that vulnerability to climate shocks is not confined to LDCs and SIDS: middle-income developing economies also face meaningful fiscal and debt risks following major climate events.

These findings have a clear policy implication: climate risk should be treated as part of sovereign risk management. Beyond traditional risk-transfer instruments such as catastrophe bonds and parametric insurance, countries may benefit from "middle-layer" tools that provide rapid liquidity or temporary debt-service relief after disasters, including Contingent Emergency Response Components and Climate Resilient Debt Clauses. These instruments are not substitutes for sound fiscal and debt management, but they can help preserve liquidity after a shock and reduce the risk that a disaster escalates into a debt crisis. They should therefore be embedded within a broader disaster risk-layering strategy that maintains market credibility while improving fiscal resilience.

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3. The World's Collective Disaster Memory Must Be Preserved (2026), https://openletter.earth/the-worlds-collective-disaster-memory-must-be-preserved-66c88c44

ANNEX

Multicollinearity

To verify that the estimated effects of climate disasters are not distorted by correlations with other economic or institutional variables, we examined the Variance Inflation Factors (VIF) for all predictors. As shown in Table A.1, we use the Generalized Variance Inflation Factor (GVIF) to account for categorical variables such as income groups. All adjusted GVIF values remain well below the conservative threshold of 2. This indicates that multicollinearity is unlikely to materially distort the estimated coefficients.

TABLE A.1: VARIANCE INFLATION FACTORS (MULTICOLLINEARITY CHECK)

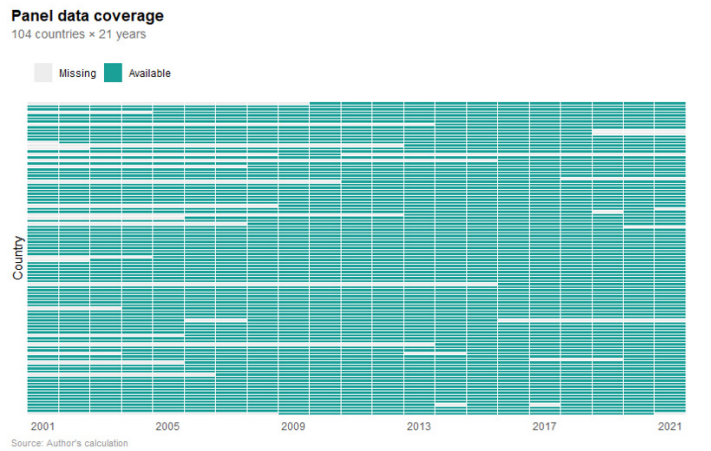
Variable	Adjusted GVIF
Climate Disaster	1.13
Log Debt/GNI (Lagged)	1.23
Log Debt Service/Exports (Lagged)	1.14
Log Vulnerability (Lagged)	1.41
Log Readiness (Lagged)	1.22
Log GDP PPP (Lagged)	1.26
Income Group	1.17

Note: An adjusted GVIF value close to 1 indicates no collinearity. Values below 2 are widely considered safe for inference.

Panel Coverage

The estimation sample comprises an unbalanced panel of 104 countries over 2001-2021, yielding 1,966 country-year observations. Seventy-one countries are observed throughout the full period, while 33 have shorter coverage due to gaps in World Bank external debt data. Figure A.1 shows data availability by country and year; coverage is broadly even over time, supporting the use of year fixed effects in the baseline specification.

FIGURE A.1 - PANEL DATA COVERAGE BY COUNTRY AND YEAR



Authors' calculation

Robustness to the COVID-19 Period

To assess whether the results are driven by the pandemic, we re-estimated all four specifications excluding 2020 and 2021. All other modelling choices, including the default definition, climate-disaster measure, lagged controls, and fixed effects, were unchanged. Table A.2 compares the estimated climate-disaster effects with the full-sample results.

The estimated effect of climate disasters remains statistically significant across all specifications and is, if anything, slightly larger when the COVID-19 years are excluded. Point estimates increase by around 0.2 percentage points, while the modest rise in standard errors is consistent with the smaller sample size. Overall, the results do not appear to be driven by the COVID-19 period.

TABLE A.2: CLIMATE DISASTER EFFECT, FULL SAMPLE VERSUS EXCLUDING COVID YEARS

Model	Full sample	Excl. COVID	Difference
(1) Fixed Effects (LPM, two-way, DK SEs)	2.47**	2.67**	+0.20
	(1.18)	(1.32)	
(2) Random Effects (LPM, DK SEs)	2.15***	2.35***	+0.20
	(0.80)	(0.86)	
(3) Mixed-Effects (Logit, AME)	2.31**	2.53**	+0.22
	(0.98)	(1.03)	
(4) GEE (Logit, AME)	2.32***	2.53***	+0.21
	(0.76)	(0.87)	
Observations	1,966	1,772	
Default onsets	88	81	

Notes: Effects and standard errors are reported in percentage points; logit effects are average marginal effects. Driscoll–Kraay standard errors with a maximum lag of 2 are used for the LPM specifications, and robust standard errors for the logit specifications. Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The COVID-excluded sample omits 2020–2021.

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