Climate Risks and Fiscal Debt Trap: Evidence and Gaps.

Discussion Paper

Authors: Dhruv Singh, Dhruba Purkayastha, Gireesh Shrimali

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Abstract

This paper reviews the empirical evidence for a climate–fiscal–debt trap: a hypothesised feedback loop in which climate shocks worsen fiscal outcomes and sovereign risk, tighter financing conditions compress resilience and transition investment, and resulting underinvestment deepens future vulnerability and fiscal stress. Rather than treating the "trap" as a metaphor, we assess each link in the chain against a falsifiable standard of loop closure. The evidence is unevenly distributed. A substantial literature now supports the first two links: climate shocks and vulnerability can generate persistent fiscal scarring and raise sovereign distress risk, and sovereign borrowing costs respond to climate vulnerability, particularly in exposed developing economies, though estimates vary across instruments and horizons. The evidence weakens considerably on the later links. The claim that sovereign repricing compresses adaptation and mitigation investment remains more often asserted than empirically identified, and the proposition that investment shortfalls feed back into renewed fiscal deterioration and sovereign stress rests primarily on model-based and scenario-driven work rather than cross-country panel evidence. We also assess proposed loop-dampening instruments — including high-quality public investment, state-contingent debt design, and debt-for-climate operations — and find that while several are conceptually credible, robust ex post evaluation remains thin and highly design-dependent. The central research gap is therefore not the absence of relevant literature but the absence of integrated empirical designs that trace a common shock through the full sequence from climate exposure to fiscal scarring, sovereign repricing, investment compression, and renewed vulnerability. We conclude by specifying the identification challenges that must be resolved to move the climate–fiscal–debt trap from plausible working theory to established empirical regularity.

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Executive summary

This discussion paper treats the climate–fiscal–debt trap as a testable empirical hypothesis, not a metaphor. The literature already documents several important links between climate risk, fiscal stress, sovereign pricing, and investment constraints. But it does not yet establish full empirical loop closure. The evidence is strongest on the first two links in the chain and weakest on the investment-mediated feedback that would turn repeated shocks into a self-reinforcing system.

Climate risk can generate persistent fiscal scarring and raise sovereign distress risk.

The strongest empirical support in the literature is for the claim that climate shocks and vulnerability can worsen fiscal balances and raise debt burdens over more than a single year. Large-panel evidence is broadly consistent with persistent fiscal scarring, and some studies also find that major disasters increase the probability of default onset. This supports the view that climate risk is not only a short-run reconstruction problem but a macro-fiscal one. However, the evidence is not uniform across hazards and settings: some disaster studies find spending increases without a clean debt surge, suggesting that grants, concessional finance, debt relief, and time aggregation can obscure underlying fiscal stress. The main gap is therefore not whether the fiscal channel exists, but how cleanly it can be identified across samples and measures.

Sovereign risk metrics respond to climate vulnerability, especially in more exposed developing economies.

The literature increasingly supports the existence of a climate premium in sovereign borrowing costs. Medium-run yield and spread studies provide the clearest evidence, with stronger effects in climate-vulnerable emerging and developing economies than in advanced economies. There is also some evidence that markets respond to policy and transition signals, although these effects are smaller and more method sensitive. By contrast, high-frequency CDS evidence is more contested, and sovereign ratings appear to incorporate climate risk only partially and often with modest magnitude relative to conventional macro-fiscal determinants. The key gap here is not sign but size: the literature is more confident that climate risk affects sovereign pricing than it is about the magnitude, persistence, and policy relevance of that effect across instruments and horizons.

The claim that sovereign repricing compresses resilience and transition investment remains plausible but weakly identified.

This is the first major bottleneck in the loop. There is credible evidence, much of it outside the sovereign climate-risk literature narrowly defined, that high perceived risk and high financing costs can depress long-horizon investment. Model-based work on a “climate investment trap” in developing economies reinforces that intuition. But in the sovereign-risk literature proper, this channel is still more often asserted than demonstrated. Very few studies identify a causal chain

from sovereign repricing or tighter market access to measured changes in adaptation or mitigation investment. The main gap is therefore direct: the literature has not yet robustly quantified how much sovereign financing stress reduces resilience or transition investment in cross-country data.

The proposition that lower resilience investment raises future vulnerability and losses is supported in principle, but the feedback into sovereign stress is not yet well established.

Adaptation and resilience studies broadly support the idea that investment can reduce future losses. But the evidence is uneven precisely where the debt-trap hypothesis matters most. Much of the strongest work is model-based, and major assessment literature remains cautious about adaptation effectiveness in lower-income settings. In addition, some widely cited “high return” resilience claims are not well grounded once traced back to their evidentiary base. The gap is therefore not whether resilience investment matters, but whether underinvestment can be shown empirically to feed back into later fiscal deterioration and sovereign repricing in a dynamic loop.

Proposed loop-dampeners are conceptually credible, but evaluation remains thin and highly design-dependent. Evidence: weak to moderate, depending on instrument.

The literature suggests three broad breakpoints for dampening amplification: reducing the fiscal hit from shocks, limiting sovereign repricing and rollover stress, and preserving resilience or transition investment under tighter financing conditions. The strongest case is **for high-quality public investment**: evidence suggests that investment quality can determine whether scaling investment reduces or increases sovereign risk. There is also a credible case **for state-contingent debt design** and for debt structures that reduce external-debt-service stress aftershocks. However, many proposed instruments—especially debt-for-climate swaps and related operations—are not well supported by ex post evaluation. Their usefulness appears conditional on design, governance, creditor coordination, and counterfactual financing options. The literature therefore offers plausible candidates for dampening amplification, but not a settled menu of proven solutions.

Methodological debates are not peripheral; they determine what can be identified.

The main contestations concern horizon, instrument choice, and measurement. Yields, CDS, and ratings do not capture the same object. Composite vulnerability measures often mix physical exposure with governance and development capacity. Transition policy can reduce long-run risk while worsening near-term fiscal pressure if financed poorly. And many solution claims are weakened by transaction complexity, limited scalability, or lack of evaluation. These debates matter because they determine whether the literature is identifying a dynamic loop or simply documenting parallel correlations.

Overall, the literature supports a climate–sovereign debt nexus, but not yet a closed empirical feedback loop.

The most defensible reading of the evidence is that the climate–fiscal–debt trap remains **a plausible working theory with meaningful support on individual links**, rather than a fully established empirical system. Evidence is strongest for **climate risk → fiscal stress and climate vulnerability → sovereign pricing.** Evidence is weaker **for sovereign repricing → reduced resilience investment** and weaker still for **investment shortfalls → renewed fiscal and sovereign stress.** The central research gap is therefore not the absence of literature, but the absence of integrated empirical designs that trace the same shock through the full sequence from climate exposure to fiscal scarring, sovereign repricing, investment compression, and renewed vulnerability.

Introduction

Climate-related disasters are increasingly a balance-sheet shock for developing countries, not just a humanitarian or infrastructure shock[1–3]. Floods, droughts, and storms raise immediate public spending on relief and reconstruction, often financed through borrowing[4,5]. At the same time, fiscal revenues can weaken as output falls and tax bases erode. The result is mechanical: debt rises, fiscal space shrinks, and long-horizon investment is deferred—precisely when resilience and low-carbon transition investment should be scaling.

This matters because the macro-fiscal hit can be amplified by markets. When investors and rating agencies interpret climate vulnerability as a threat to repayment capacity, sovereign risk premia can widen and credit ratings can deteriorate, increasing borrowing costs. In many developing economies, this interacts with pre-existing drivers of high capital costs—exchange-rate volatility, regulatory uncertainty, weak contract enforcement, and project-completion risk—creating a financing environment where even "good" public investment becomes harder to execute. The channel is not abstract. Where banks and domestic financial institutions hold large volumes of sovereign debt, climate-linked deterioration in sovereign credit quality becomes a financial stability concern, not only a public finance concern.

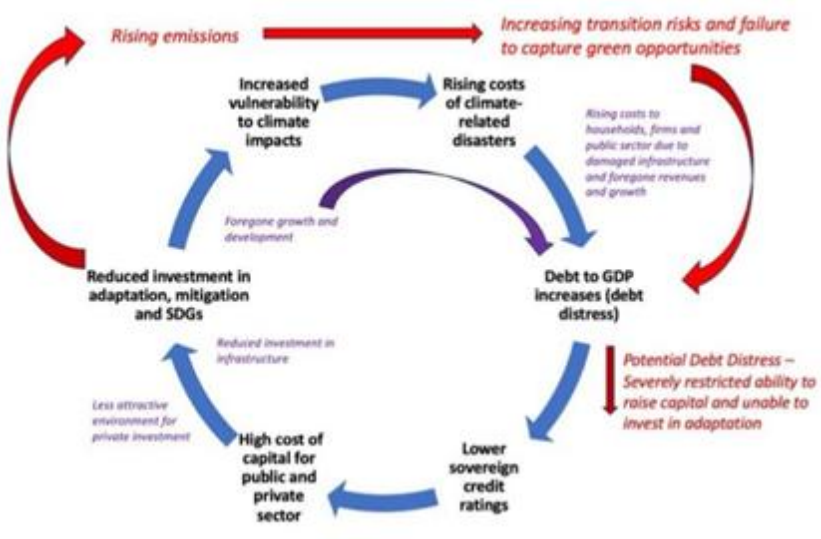

Figure 1. The climate–fiscal–debt trap as a self-reinforcing loop. Climate impacts raise disaster-related losses and public expenditure, increasing debt-to-GDP and sovereign risk. Higher borrowing costs and weaker market access then compress public and private investment in adaptation, mitigation, and development, which increases future vulnerability and damages. The loop can also interact with transition risk (missed green opportunities and rising emissions), worsening long-run growth and fiscal space.

These interactions motivate the concept of a climate–fiscal–debt trap: a testable feedback loop in which climate shocks and vulnerability worsen fiscal outcomes and debt dynamics; sovereign repricing and market-access constraints then compress resilience and transition investment; and underinvestment increases future losses (and/or slows decarbonization), feeding back into

vulnerability and risk premia. The policy stakes are high because the “obvious” response—borrow to rebuild—can itself raise refinancing costs and tighten future fiscal space, locking countries into a self-reinforcing cycle.

Conceptual framework

A climate–fiscal–debt trap can be understood as a dynamic macro-financial mechanism in which climate risk affects the sovereign not only through realized physical or social damage, but through the interaction of fiscal adjustment, capital-market pricing, and investment capacity over time. The central theoretical claim is not simply that climate shocks worsen public finances, nor only that sovereign markets price climate vulnerability. It is that these effects can become mutually reinforcing under identifiable conditions, such that an initial shock or persistent vulnerability reduces fiscal space, worsens sovereign financing conditions, compresses resilience and transition investment, and thereby increases future exposure to loss and further repricing. In this sense, the "trap" is a conditional amplification mechanism rather than a metaphor or a purely descriptive label.

This literature review therefore does one thing carefully: it assembles the evidence for each arrow of the loop and clarifies what it would take to close the loop empirically, rather than merely describe it. It proceeds from (i) evidence that physical risk propagates into fiscal stress, debt, and default risk, to (ii) evidence that climate risk is priced into sovereign borrowing costs (with instrument- and horizon-specific signals), and then to (iii) what the literature suggests can dampen amplification through debt design, investment quality, and international financial architecture. The objective is not a policy wish list. It is to pin down the mechanisms and measurement choices that turn “trap” from narrative into identification.

A “climate–fiscal–debt trap” is a two-way feedback system:

1. climate shocks/vulnerability worsen fiscal outcomes and debt dynamics;
2. sovereign repricing and market-access constraints then compress resilience/transition investment;
3. underinvestment increases future losses (and/or slows decarbonization), feeding back into vulnerability and risk premia.

This section shows the literature already identifies the arrows; the contribution is to define and test loop closure as a falsifiable claim. Two strands of recent work sharpen the case for treating climate–sovereign debt interactions as a genuinely self-reinforcing loop rather than a loose metaphor.

First, the “loop” language is not merely rhetorical.

Zenios (2024)[2] explicitly reviews mechanisms that can activate a climate–sovereign debt “doom loop,” emphasizing fat tails, feedbacks, and fiscal uncertainty around both physical damages and climate policy. The author frames the nexus as a systemic macro-fiscal problem: climate shocks can

depress growth (weakening the debt-to-GDP denominator) while simultaneously widening deficits through adaptation/mitigation outlays, disaster response, and other contingent liabilities (raising the numerator). In parallel, sovereign risk premia can rise as investors reassess both physical and transition exposures (making refinancing harder and debt service more expensive) which further tightens fiscal space. Critically, it is noted that a growing view among investors that climate risks are already materializing yet remain underpriced. This is creating scope for abrupt repricing that can destabilize debt markets. Hence, this increases a push toward forward-looking integration of climate scenarios into debt sustainability analysis and credit assessments. The point is not just that climate affects debt, but that interacting channels can plausibly lock countries into self-reinforcing deterioration.

Second, climate vulnerability is priced into sovereign borrowing costs.

Using a **46-country panel (1996–2016),** Kling et. al (2025)[6] estimate that highly vulnerable economies pay **~1.17 percentage points** more on their cost of debt on average, which is equivalent to **~USD 62bn** in additional interest. The paper also points to a practical offset: stronger **social readiness** (captured by indicators such as **education and ICT capacity**) is associated with **lower yields,** suggesting investments in adaptive capacity can compress risk premium. Moreover, the authors note that the mechanism is not just about pricing. Higher vulnerability also raises the risk of market exclusion, squeezing finance when resilience investment is most needed and locking in a feedback loop in which higher spreads and constrained access curtail resilience spending, deepening future vulnerability.

To move beyond metaphor, we adopt a testable, standards-based definition of a feedback loop. The first condition is that a loop exists only if plausibly exogenous climate shocks (or vulnerability shocks) leave a persistent imprint on fiscal balances/debt dynamics and sovereign risk pricing. The second leg is causal in the other direction. Tighter spreads or weaker market access must materially compress resilience and transition investment (or investment quality), and that underinvestment must predict higher subsequent vulnerability or climate losses (or, on the transition side, higher emissions intensity or slower decarbonization). This definition maps directly onto the mechanisms reviewed by Zenios (2024)[2] and the investment-underinvestment channel emphasized by Kling et. al (2025)[6].

A climate–fiscal–debt feedback loop is easy to narrate but harder to validate as a causal, self-reinforcing system. The recent literature is increasingly comfortable with the language of feedbacks and “doom loops,” and Zenios (2024) is particularly useful in framing the nexus as one of interacting channels, fat tails, and potentially destabilizing repricing. But for this discussion paper, the key question is not simply whether adjacent relationships exist. It is whether the available evidence is sufficient to establish empirical loop closure.

A defensible working definition of loop closure in this setting has three requirements.

1. First, climate shocks or shifts in vulnerability/exposure must leave persistent fiscal or debt scarring rather than a one-year disturbance.
2. Second, sovereign risk pricing, ratings, or market access must respond materially either to that deterioration or to climate risk itself, in a way that can be distinguished from broader global risk sentiment.
3. Third, and most importantly, tighter sovereign financing conditions must causally compress resilience or transition investment, and that investment shortfall must in turn raise subsequent losses, vulnerability, or fiscal stress.

Without that final step, literature may show a sequence of plausible relationships without demonstrating a self-reinforcing empirical system.

This framing is important because the evidence is not evenly distributed across the loop. The literature is relatively strong on the first two requirements: there is meaningful evidence that climate risk can worsen fiscal outcomes and that sovereign risk metrics respond to climate vulnerability, particularly in more exposed developing economies. By contrast, the investment-mediated feedback leg remains much less firmly established. The central gap, therefore, is not simply absence of evidence, but fragmentation: selective robustness on individual relationships, weaker identification on the transmission from sovereign repricing to investment compression, and limited integrated testing of the end-to-end mechanism.

The sections that follow assess four linked relationships in turn:

1. climate risk and vulnerability to fiscal stress and debt deterioration;
2. fiscal deterioration and climate vulnerability to sovereign repricing and market access;
3. sovereign repricing to reduced resilience and transition investment; and
4. investment shortfalls to future losses, vulnerability, and renewed fiscal stress.

This relationship-by-relationship structure allows the paper to distinguish what is already well supported from what remains contested, under-measured, or only weakly evidenced.

Evidence that physical climate risk propagates into fiscal stress, debt, and default risk

Physical climate risk appears to transmit into fiscal stress, debt deterioration, and, in tail cases, sovereign distress, but the evidence is stronger on persistent fiscal scarring than on a universally uniform debt response across all settings.

The most persuasive studies show multi-year worsening in fiscal balances and debt dynamics following climate vulnerability or disaster shocks, particularly in more exposed and lower-income economies. At the same time, the literature is not perfectly one-directional: some disaster studies find short-run deficit financing without a clear debt surge, indicating that financing structure, external assistance, and time horizon all shape what is observed. This section therefore treats the fiscal transmission channel as meaningful and policy-relevant, but heterogeneous in strength and empirical expression.

Using panel local projections for 184 economies (1995–2021), Le et. al (2025)[7] find climate vulnerability shocks deteriorate fiscal balances and raise debt-to-GDP, documenting multi-year debt dynamics consistent with a persistence channel rather than a one-off shock. Disasters provide a more direct fiscal transmission mechanism. Benali et. al (2018)[4] analyses a panel of nine middle-income countries (2000–2014) and reports unidirectional causality from natural-disaster measures to budget deficits, alongside evidence that post-disaster reconstruction is financed through higher public debt. The sample is narrow, but the identification focus is useful. It isolates a concrete bidirectional relationship between disasters and budget deficits that activate the fiscal side of the loop.

The literature also connects disasters to sovereign distress and default risk, which matters if the "trap" is framed as a sovereign-risk mechanism rather than a purely macro-fiscal story.

Klomp (2017)[5] examines roughly 115 countries (1985–2010) and finds that large-scale disasters are associated with an increase of about three percentage points in the probability of default onset, arguing that the effect operates through deteriorating public finances and weakened debt sustainability. It is vital to note that default is a tail outcome. Consistent with that, the author also notes evidence from earlier work that fiscal positions may revert in the long run after many disasters, even if large events can still trigger default in the short run.

A further amplification route runs through macro-financial feedbacks, not only primary-balance arithmetic.

In climate–macro–financial simulation analyses, Lamperti et. al (2019)[8] estimate climate damages can materially raise the frequency of banking crises, with bank rescues imposing sizeable fiscal burdens (several percent of GDP per year in their simulations) and potentially doubling public debt-to-GDP. This is the second-round channel. Even without explicitly modelling banks, these results

motivate a credible pathway from climate shocks to sovereign balance sheets that extends beyond reconstruction spending.

A further strand of the literature uses higher-frequency fiscal data and points to important asymmetries across country groups.

Multiple panel studies[3,9] find that developed countries tend to respond to disasters in a counter-cyclical manner, whereas developing countries display pro-cyclical responses, including lower spending and higher revenues after large catastrophes. This is not yet evidence of a full debt trap, but it does suggest that fiscal adjustment is systematically harsher in precisely the settings where amplification is most plausible[3,9].

The evidence is also not internally uniform.

A Caribbean panel VAR using a physically derived hurricane destruction index finds that government spending rises and short-term deficit financing occurs after severe storms, but public investment, debt, and tax revenue do not respond significantly[10]. This is an important internal contradiction within the fiscal-stress channel: not all disaster settings produce a clean disaster-to-debt-surge pattern. One plausible explanation is that grants, concessional finance, debt relief, or other external support can temporarily blunt measured debt increases even when underlying fiscal stress is acute[11]. The sovereign-distress evidence is also somewhat broader than the event-based studies cited above suggest. Complementing cross-country default-onset work, an International Monetary Fund working paper estimating logit models for 116 countries over 1995–2017 finds that higher climate vulnerability is associated with higher default probability, while greater resilience is associated with lower default probability. This strengthens the interpretation that the fiscal effects of climate risk are not limited to reconstruction spending or short-run budget deterioration, but can extend into sovereign creditworthiness more broadly[12].

Taken together, literature provides meaningful support for the claim that climate shocks can leave persistent fiscal scars and, under some conditions, raise sovereign distress risk. But the evidence also comes with recurring identification problems.

1. First, “disaster” is not fully exogenous in most datasets, because observed losses reflect not only hazard but also exposure and vulnerability.
2. Second, widely used vulnerability and resilience measures are not plug-and-play proxies for physical climate risk: they often embed governance, development, and institutional capacity, which can blur the distinction between climate-specific effects and broader structural fragility.

For the purposes of this paper, the key conclusion is that this leg of the loop is supported more robustly than the later investment-mediated channels, but not uniformly across samples, hazards, or empirical strategies.

Evidence that sovereign risk and cost of capital respond to physical and climate disaster risk

The next step is to ask whether climate vulnerability and fiscal deterioration are reflected in sovereign risk metrics themselves. This is the key bridge from macro-fiscal stress to financial transmission. The literature now provides meaningful evidence that climate risk is priced, but the strength and policy relevance of that pricing depends on the instrument being studied. Medium-run yields and spreads, high-frequency CDS, and sovereign ratings do not capture the same object, and they do not move over the same horizon. This section therefore distinguishes carefully between these metrics before assessing how far the pricing channel can be treated as empirically established.

The existence of a relationship between climate vulnerability and yields or spreads is no longer speculative, especially for emerging and climate-vulnerable economies.

Climate vulnerability is associated with higher sovereign yields and spreads, while resilience is associated with lower borrowing costs, with larger effects in developing countries. The same study is also useful methodologically: it deploys lagged climate indices and dynamic panel methods to address endogeneity, while explicitly acknowledging the familiar limits of system-GMM and the risks of instrument proliferation[12]. An Asian Development Bank Institute working paper for 40 economies reports a similar pattern, with climate vulnerability raising bond yields and resilience lowering them, but with statistically insignificant effects in advanced economies and much larger effects in emerging and high-risk groups. A more recent study in the same lineage estimates that climate vulnerability raises the cost of debt by roughly 1.17 percentage points in climate-vulnerable countries, implying a historically large aggregate interest burden[13]. At the same time, these estimates should be read with caution, since they often combine liquid and illiquid markets and rely on yield measures drawn from different underlying pricing conventions.

Evidence that markets price policy and transition signals is more mixed, but it is not absent.

A difference-in-differences study around the Kyoto Protocol and Paris Agreement finds modest declines in sovereign yields for countries that commit to major climate agreements[14], consistent with a credibility or investor-reward channel rather than a large repricing effect[15]. Related panel work using transition proxies, including emissions intensity, natural-resource rents, and renewable-energy shares, also finds statistically significant relationships with sovereign spreads, although the direction and size of the effect vary across advanced and developing economies[16,17]. The implication is not that transition risk is already priced in a clean and uniform way. It is that the sovereign-risk literature has moved beyond physical risk alone, even if the pricing of transition exposure remains uneven and method-sensitive.

The sharpest fault line in this literature concerns the difference between yields, CDS, and ratings.

High-frequency CDS studies produce more contested results than the medium-run yield literature. One open-access study using daily sovereign CDS and local projections finds only small and short-lived effects for some disaster categories, little evidence of anticipatory pricing, and a dominant role for regional and global spillovers[18,19]. By contrast, Euro-area CDS evidence reports positive disaster effects and interprets part of the transmission as contagion, with better climate performance associated with weaker contagion intensity[16,20]. The sensible synthesis is not that one set of studies is correct and the other is wrong. It is that CDS and yields price different bundles over different horizons[21], and that institutional setting matters. A parallel literature examines sovereign ratings, which matter because they can affect mandates, investor eligibility, and market access even where the immediate yield effect is small. However, a recent European Central Bank research bulletin reaches a more qualified conclusion: physical risk measures and disaster frequency may be associated with weaker ratings, but the economic magnitude remains small relative to conventional macro-fiscal determinants, while transition risk factors are largely absent in baseline estimates[12]. This suggests that climate-risk incorporation in ratings may be real but still limited in scale and horizon.

Taken together, the literature supports the view that sovereign risk metrics do respond to climate risk, but not in a single, uniform, or instrument-invariant way. The strongest evidence comes from medium-run yield and spread studies, particularly for developing and climate-vulnerable economies. By contrast, CDS evidence is more sensitive to horizon and contagion effects, while ratings appear to incorporate climate risk only partially and often with modest economic magnitude. For the purposes of this paper, the implication is straightforward: the pricing channel is real, but its empirical meaning depends on whether the object of interest is rollover costs, event-driven repricing, or rating and market-access thresholds.

Evidence that sovereign repricing compresses resilience and transition investment

The third link in the hypothesised feedback loop posits that sovereign repricing and deteriorating market access curtail public and private investment in adaptation, resilience, and low-carbon transition. This channel is, in principle, the critical transmission mechanism: it is what transforms a sequence of fiscal and financial shocks into a self-reinforcing dynamic rather than a series of discrete disturbances. Yet it is also the link for which the empirical foundation is most tenuous.

A body of work situated largely outside the sovereign climate-risk literature proper lends indirect support to the proposition. The broader investment and development finance literatures have long established that elevated country risk premia and constrained access to external capital markets tend to depress long-horizon public and private investment, particularly in sectors characterised by delayed returns, high upfront capital intensity, and exposure to policy and regulatory uncertainty[17,22]. Ameli et al. (2021) [22] formalise this intuition in a model of the "climate investment trap," demonstrating that the elevated cost of capital faced by developing economies can render low-carbon investments unviable at the margin, thereby perpetuating carbon-intensive development trajectories and reinforcing the macroeconomic fragilities that gave rise to higher financing costs in the first instance.

The difficulty is that the sovereign climate-risk literature has, for the most part, not subjected this channel to direct empirical scrutiny. The typical mode of engagement is assertion rather than estimation: studies observe that climate-vulnerable sovereigns face higher borrowing costs or more constrained fiscal space and then infer (often in concluding remarks or policy discussion sections) that this must compress adaptation or mitigation expenditure. What is conspicuously absent is a body of reduced-form or structural evidence that traces sovereign repricing events or shifts in market access to measured changes in resilience or transition investment at the country level. The consequence is that the investment-compression channel remains, in empirical terms, an analytically necessary but insufficiently documented component of the loop. Without credible identification of this link, the literature can establish that climate shocks propagate into fiscal deterioration and sovereign repricing, but it cannot yet demonstrate that the repricing itself generates the underinvestment that would close the feedback circuit.

Evidence that investment shortfalls raise future vulnerability and renew fiscal stress

The final leg of the loop requires that insufficient investment in adaptation, resilience, or decarbonisation translates into heightened future vulnerability, greater climate-related losses, or renewed fiscal deterioration — thereby completing the circuit from climate exposure through sovereign stress and back again.

The theoretical case is well articulated. Adaptation and resilience studies provide broad support for the proposition that well-designed and adequately resourced interventions can reduce the severity of future climate damages[3,23]. Model-based analyses that couple integrated assessment frameworks with sovereign debt sustainability tools similarly indicate that persistent underinvestment in resilience can worsen long-run debt trajectories and sovereign risk profiles[1,2,9]. These contributions are valuable insofar as they formalise the dynamic interdependence between investment decisions and subsequent fiscal outcomes.

The empirical record, however, does not yet sustain the weight that the feedback-loop hypothesis places upon it. Three limitations warrant particular emphasis. First, the most compelling results are derived from calibrated models and scenario exercises, which, while internally coherent, remain sensitive to parametric assumptions and are not equivalent to observing the feedback mechanism in cross-country panel data. Second, the adaptation-effectiveness literature is notably more cautious in lower-income and institutionally constrained settings, precisely the contexts in which the debt-trap dynamic is most frequently invoked. The heterogeneity of adaptation returns across governance environments, hazard types, and investment modalities introduces substantial uncertainty into any generalised claim about the fiscal benefits of resilience expenditure. Third, and most critically, very few studies attempt to trace the full empirical sequence from measured underinvestment to subsequent increases in climate losses, fiscal deterioration, or sovereign repricing. The existing literature can establish that investment matters for resilience in specific contexts, but it has not yet demonstrated that observed shortfalls in such investment feedback, in a quantifiable and systematic manner, into the fiscal and sovereign-risk dynamics from which the loop departs. Until that empirical architecture is in place, the end-to-end feedback mechanism remains a theoretically coherent and policy-relevant conjecture rather than an established empirical regularity.

Closing the loop: How to dampen amplification

Breaking the loop requires more than identifying plausible policy tools; it requires asking which interventions act on the key amplification margins and how strong the supporting evidence is. In practice, the literature points to three broad breakpoints: reducing the fiscal hit from shocks, limiting sovereign repricing and rollover stress, and preserving resilience or transition investment when financing conditions tighten. But the evidentiary standard is weaker here than in the earlier sections. Much of this literature is stronger on mechanism plausibility, design logic, and model-based reasoning than on clean ex post evaluation. This section therefore treats proposed loop-dampeners as conditional breakpoints rather than settled solutions.

Higher resilience investment upfront can reduce the severity of the loop by lowering future losses and, with them, sovereign financing costs, but governance and execution quality condition whether that effect is strong enough to yield a net benefit relative to delayed or absent investment.

As mentioned earlier, Kling et al. (2025)[6] find that readiness/social preparedness is associated with lower yields. Quality is the constraint. A recent cross-country study constructing a public investment quality index for 120 economies (2000–2021) similarly finds that scaling up public investment reduces sovereign risk when investment quality is high but can raise sovereign risk when quality is low (especially for sub-investment-grade sovereigns), while high-quality scale-ups do not undermine debt sustainability[24]. Framed against the relevant counterfactual, the implication is that upfront, high-quality resilience investment can weaken the loop—because avoided future damages and lower risk premia may outweigh the initial fiscal cost—whereas low-quality investment can instead intensify it. This is directly usable as a breakpoint: “closing the loop” may require not only more investment, but demonstrably high-quality investment.

Debt design can reduce the severity of the loop even when it does not directly lower physical damages.

Mallucci (2022)[25] shows in a quantitative sovereign default model calibrated to hurricane-exposed Caribbean economies that disaster clauses (especially those allowing debt reduction) can improve borrowing terms, mitigate market-access deterioration, and soften welfare losses under climate change. Empirically, Cheng and Chang (2025)[26] find that rare disaster shocks increase sovereign default risk, and that local-currency-denominated external debt mitigates this effect. Their mechanism tests show that disasters raise default risk through higher external debt service and government expenditure, while LCED weakens only the external-debt-service channel by reducing the USD value of debt service after post-shock depreciation. Taken together, these studies suggest that debt design can dampen amplification on the financing side of the loop by reducing rollover, repricing, and debt-service stress. However, these instruments do not automatically generate higher

resilience investment; rather, they preserve fiscal space that may help prevent resilience spending from being crowded out.

Climate-linked debt operations exist, but they are not free lunch and must be designed against perverse incentives and coordination failure.

Chamon et. al (2024)[27] examine debt-for-climate swaps and argue that, as fiscal support for climate investment, swaps are generally dominated by conditional grants; as a way to fund climate investment and reduce debt, they are generally dominated by conditional grants plus comprehensive restructuring (or climate-conditional restructuring). Swaps can be second-best. They nevertheless outline a narrow efficiency case where swaps can reduce debt risks while avoiding the costs of full restructuring and stress design features that minimize free riding by non-participating creditors.

Evidence from the biodiversity "debt-for-nature" debate reinforces the implementation constraint. Nedopil et. al (2024)[28] examine scaling potential across 67 countries at risk of debt distress, quantifying biodiversity-priority protection relative to debt stocks while emphasizing that implementation is complex and that scalability and effectiveness are difficult to establish. Transaction frictions are not noisy. The authors conclude the transferable point is that loop-breaking instruments face governance, transaction, and creditor-coordination constraints that must be treated as part of feasibility, not an afterthought[29].

A central limitation of the existing literature is that the mechanism most often invoked in policy discussion—higher sovereign risk compressing resilience and transition investment—is still only weakly identified in cross-country empirical work. There is credible evidence, much of it outside the sovereign climate-risk literature narrowly defined, that high perceived risk and high financing costs depress long-horizon investment, especially where returns are delayed and risks are front-loaded. A prominent "climate investment trap" model for developing economies formalizes a similar self-reinforcing dynamic, with elevated financing costs delaying low-carbon investment and feeding back into instability. But in the sovereign-risk literature proper, this channel is more often asserted than estimated: studies frequently note that higher borrowing costs or debt problems can constrain adaptation and mitigation spending yet rarely provide a causal estimate of the effect of sovereign repricing on measured investment outcomes. This matters for interpretation. The case for these instruments is often economically sensible, but the underlying bottleneck they seek to address remains only partially measured.

Taken together, the literature suggests that the loop can in principle be dampened through better investment quality, more state-contingent debt design, and financing instruments that avoid mechanically worsening debt distress. But the evidence base is uneven. What is strongest is the logic that these tools could act on identifiable breakpoints in the loop; what is weaker is robust empirical evaluation of whether they preserve investment, reduce future vulnerability, or durably

soften sovereign repricing in real-world settings. For the purposes of this paper, the key takeaway is therefore cautious: the literature offers credible candidates for dampening amplification, but not yet a fully evidenced menu of loop-breaking solutions.

Contestations and methodological debates

The main disputes in this literature are no longer about whether climate risk matters for sovereign debt. They concern how that relationship should be measured, over what horizon it appears, and whether the available evidence identifies a self-reinforcing system rather than a set of adjacent correlations. This matters because the same empirical result can look strong or weak depending on the object being priced, the time window being used, and the choice of climate-risk proxy. The methodological debates are therefore not peripheral to the paper's argument; they determine whether claims about a climate–fiscal–debt loop are credible, overstated, or simply not yet identified.

The most productive contestations in this literature are not about whether climate matters, but how, when, and through which observable signals it matters for sovereign risk and fiscal dynamics.

The first debate concerns the strength and timing of market pricing.

As noted earlier, Cevik & Jalles (2022)[12] alongside Kling et al. (2025)[6], report economically meaningful relationships between vulnerability/resilience and sovereign borrowing costs using medium-frequency yields/spreads. Agnello (2025)[19] uses high-frequency CDS evidence, by contrast, pointing to small and short-lived effects for some hazard types, with limited movement even when disasters are anticipated, and highlights the role of broader spillovers. Horizon is part of the identification. This disagreement motivates two design choices:

1. focusing on horizons that match fiscal adjustment and debt dynamics (years, not days), and
2. iterating pricing, market access, and rollover risk as distinct outcomes rather than interchangeable indicators.

A second debate concerns what "climate risk" measures contain.

Kling et. al (2025)[6] show that ND-GAIN subcomponents can embed projections and governance proxies; they adjust the index construction (e.g., excluding exposure elements driven by projections and using PCA to address multicollinearity), underscoring that composite indices are not plug-and-play risk measures. Saxena and Singh (2024)[30] use simpler physical exposure proxies (e.g., coastal population exposure) in a difference-in-differences design around climate agreements, trading breadth of concept for cleaner identification. Risk is not one variable. A feedback-loop claim is easier to defend if robustness is shown across (a) realized shock measures (events) and (b) structural vulnerability/resilience indices, while treating these as conceptually distinct objects rather than substitutes.

A third debate sits at the intersection of transition policy and debt sustainability.

The transition can lower long-run physical risk, but it can also generate near-term fiscal pressure if financed poorly. One dynamic general-equilibrium study argues that transition pathways relying heavily on expenditure-based measures can threaten debt sustainability by raising default probabilities and interest rates. Spending is not automatically stabilizing. This sharpens the paper's narrative discipline: "closing the loop" is not synonymous with "spend more," but with spending composition and financing design that avoids worsening debt distress[31].

A fourth debate concerns instrument efficacy versus transaction complexity.

Mallucci (2023)[25] model that disaster clauses are not uniformly welfare-improving across designs; Chamon et. al (2024) [27] argue that debt-for-climate swaps are often dominated by conditional grants and/or comprehensive restructuring except in narrow cases, and emphasize free-rider problems. Nedopil (2024)[28] further stress scalability and implementation constraints even where swap-like instruments appear attractive on paper. Design conditions are the result. These contestations help avoid a "policy wish list" and instead motivate a finance contribution: identifying leverage points and the conditions under which specific tools plausibly reduce amplification.

A further contestation concerns the evidentiary status of the loop itself.

The literature is increasingly persuasive on individual links, but much less settled on their combined magnitude and dynamic interaction. On the fiscal side, climate change can worsen debt dynamics through both denominator effects, by reducing growth, and numerator effects, by raising adaptation, recovery, and contingent-liability costs. On the pricing side, several studies find a climate premium in sovereign borrowing costs, especially for vulnerable emerging and developing economies. But, as Zenios notes, literature is stronger on sign than on size, and still weaker on integrated closure. The later legs of the loop remain the thinnest: the claim that tighter financing conditions compress adaptation or mitigation investment, and that this underinvestment then raises subsequent vulnerability and sovereign stress, remains supported more by model-based and scenario-driven work than by reduced-form cross-country evidence. This is precisely why horizon, metric, and measurement choice are not technical footnotes; they define the boundary between plausible amplification and demonstrated loop closure.

Finally, there is a meta-level debate about disciplinary fragmentation.

A bibliometric/systematic review of climate risk and systemic risk documents rapid growth across clusters but emphasizes fragmented metrics and limited integration across macro, finance, and climate-risk traditions. This supports the paper's positioning: the contribution is not "another climate risk premium" result, but a unified, testable loop that links shocks, fiscal transmission, sovereign pricing, and investment capacity within one empirical architecture[29].

Taken together, these contestations do not weaken the case for studying the climate–sovereign nexus; they sharpen it. They show that the central challenge is not whether climate risk enters fiscal

and financial outcomes at all, but whether literature can distinguish robust transmission mechanisms from noisy or partial correlations. For this paper, the implication is methodological and substantive at once: the contribution is not to claim that a closed loop has already been proven, but to specify where the evidence is strong, where it is mixed, and where identification still breaks down. That is what allows the discussion to move from rhetoric about “debt traps” toward a more disciplined empirical research agenda.

Conclusions and future work

What remains missing is a convincing empirical demonstration of the full climate–fiscal–debt feedback loop as an integrated mechanism.

The core gap is not that the literature has ignored the relationship between climate change and sovereign debt. On the contrary, the emerging literature already documents several important parts of that relationship. Put differently, the evidence base is uneven across the loop's component arrows: some links are already reasonably well established, others remain contested, and the end-to-end amplification process is still more a plausible working theory than a fully verified empirical result.

The first loop, from climate risk to fiscal stress and debt accumulation, is supported by a substantial and growing literature.

The review shows that climate change can worsen debt dynamics through both denominator effects, by reducing growth, and numerator effects, by raising adaptation, mitigation, recovery, and contingent liability costs[1,32,33]. There is also evidence that these effects are particularly acute in vulnerable and lower-income economies, where physical risk, weaker resilience, and tighter fiscal space combine to make debt burdens harder to manage[34,35]. However, even here the evidence is not fully settled. The review notes that adaptation spending may sometimes worsen debt ratios, but in other cases have neutral effects once growth and avoided damages are taken into account[23]. That matters for the gap analysis: the literature does not speak with one voice on how strongly climate-related public spending translates into debt deterioration.

The second loop, from climate vulnerability to sovereign risk pricing, is also increasingly well supported.

Several studies find a climate premium in sovereign borrowing costs, especially for climate-vulnerable emerging and developing economies[6,12,36]. Forward-looking work on transition risk similarly suggests that sudden policy shifts and fossil dependence can raise sovereign spreads materially[37,38]. But again, Zenios (2024)[2] explicitly notes that there is "no consensus on the magnitude of the effects," even if the direction of travel is broadly consistent. This suggests that literature is stronger on sign than on size. It can show that climate risk tends to raise sovereign financing costs, but not yet with stable, generalizable estimates across methods, samples, and time horizons.

The third and fourth loops are where literature becomes thinner.

The idea that higher debt costs and weaker fiscal space then reduce a state's capacity to finance adaptation and mitigation, thereby increasing future vulnerability and feeding back into debt distress, is conceptually persuasive and increasingly discussed[22,39]. Yet the review itself frames this

as a “potential” doom loop rather than an empirically closed one. The strongest work here is forward-looking and model-based, especially studies linking integrated assessment models to debt sustainability analysis and sovereign ratings[1,9]. These papers are important because they move beyond isolated correlations and start to trace dynamic amplification. Even so, they remain scenario-driven, highly assumption-dependent, and not equivalent to observing the full loop in real-world panel data.

The unevenness of the evidence is not just a matter of quantity; it is also a matter of identification and internal contradiction.

Even in the stronger early links of the chain, results are not fully uniform across hazards, samples, and measurement strategies. Large-panel evidence is broadly consistent with persistent fiscal scarring, yet some disaster studies do not find a clean disaster-to-debt-surge pattern, suggesting that grants, concessional finance, and time aggregation can obscure underlying fiscal stress. Similarly, the sovereign-pricing literature is increasingly persuasive on direction, but much less settled on magnitude: medium-run yields and spreads tend to show clearer climate effects than high-frequency CDS, while ratings appear to incorporate climate risk only partially and often with limited economic weight relative to conventional macro-fiscal determinants. These disagreements do not invalidate the loop hypothesis, but they do show why “arrow-by-arrow” support is not the same as end-to-end empirical closure.

The unresolved question is whether those component links operate together as a self-reinforcing empirical system, under what conditions they do so, and how strongly they amplify sovereign vulnerability over time.

The sharper research gap, then, is not whether climate matters for sovereign debt. It does. Nor is it that literature has failed to identify important component relationships. It has. At present, literature remains strongest on the fiscal-scarring and sovereign-pricing legs, weaker on the investment-compression and vulnerability-feedback legs, and weakest on integrated empirical designs that trace the same shock through the full sequence from climate exposure to fiscal stress, sovereign repricing, investment shortfall, and renewed vulnerability. That is the gap this paper seeks to sharpen.

References

1. Zenios, S. A. The risks from climate change to sovereign debt. *Climatic Change* **172**, 30 (2022).

2. Zenios, S. A. The climate-sovereign debt doom loop: what does the literature suggest? *Current Opinion in Environmental Sustainability* **67**, 101414 (2024).

3. Hallegatte, S., Jooste, C. & Mcisaac, F. Macroeconomic consequences of natural disasters. *Policy Research Working Papers. Washington DC: World Bank* (2022).

4. Benali, N., Abdelkafi, I. & Feki, R. Natural-disaster shocks and government's behavior: Evidence from middle-income countries. *International Journal of Disaster Risk Reduction* **27**, 1–6 (2018).

5. Klomp, J. Flooded with debt. *Journal of International Money and Finance* **73**, 93–103 (2017).

6. Kling, G., Lo, Y. C., Murinde, V. & Volz, U. Climate vulnerability and the cost of debt. *Oxford Open Economics* **4**, odaf003 (2025).

7. Le, A. H., Park, D., Beirne, J. & Uddin, G. S. How does disaster risk impact fiscal sustainability and inequality? *Economic Modelling* **151**, 107220 (2025).

8. Lamperti, F., Bosetti, V., Roventini, A. & Tavoni, M. The public costs of climate-induced financial instability. *Nat. Clim. Chang.* **9**, 829–833 (2019).

9. Klusak, P., Agarwala, M., Burke, M., Kraemer, M. & Mohaddes, K. Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness. *Management Science* **69**, 7468–7491 (2023).

10. Strobl, E. The economic growth impact of hurricanes: Evidence from U.S. coastal counties. *The Review of Economics and Statistics* **93**, 575–589 (2011).

11. Melecky, M. & Raddatz, C. *How Do Governments Respond after Catastrophes ? Natural-Disaster Shocks and the Fiscal Stance*. https://ideas.repec.org/p/wbk/wbrwps/5564.html (2011) doi:None.

12. Cevik, S. & Jalles, J. T. This changes everything: Climate shocks and sovereign bonds⁎. *Energy Economics* **107**, 105856 (2022).

13. Kling, G., Lo, Y., Murinde, V. & Volz, U. Climate Vulnerability and the Cost of Debt. *SSRN Journal* https://doi.org/10.2139/ssrn.3198093 (2018) doi:10.2139/ssrn.3198093.

14. Volz, U. *Climate Change and Sovereign Risk*. (SOAS University of London, 2020). doi:10.25501/SOAS.00033524.

15. Beirne, J., Renzhi, N., Sugandi, E. A. & Volz, U. Financial market and capital flow dynamics during the COVID-19 pandemic. (2020).

16. Battiston, S., Mandel, A., Monasterolo, I., Schütze, F. & Visentin, G. A climate stress-test of the financial system. *Nature Clim Change* **7**, 283–288 (2017).

17. Nykvist, B. & Maltais, A. Too risky – The role of finance as a driver of sustainability transitions. *Environmental Innovation and Societal Transitions* **42**, 219–231 (2022).

18. Di Tommaso, C., Foglia, M. & Pacelli, V. The contagion effect of natural disasters in the Sovereign CDS market: Which causes? *International Review of Financial Analysis* **111**, 105102 (2026).

19. Agnello, L., Castro, V., Sousa, R. M. & Hammoudeh, S. What is the impact of natural disasters on sovereign risk? Expect the unexpected! *Finance Research Open* **1**, 100026 (2025).

20. De Santis, R. A. *The Euro Area Sovereign Debt Crisis: Safe Haven, Credit Rating Agencies and the Spread of the Fever from Greece, Ireland and Portugal*. https://ideas.repec.org/p/ecb/ecbwps/20121419.html (2012) doi:None.

21. De Angelis, L., Monasterolo, I. & Zanin, L. Look up and ahead: How climate scenarios affect European sovereign credit risk. *International Review of Economics & Finance* **107**, 105057 (2026).

22. Ameli, N. *et al.* Higher cost of finance exacerbates a climate investment trap in developing economies. *Nat Commun* **12**, 4046 (2021).

23. Catalano, M., Forni, L. & Pezzolla, E. Climate-change adaptation: The role of fiscal policy. *Resource and Energy Economics* **59**, 101111 (2020).

24. Adarov, A. & Panizza, U. Public investment quality and sovereign risk. *Journal of International Money and Finance* **161**, 103503 (2026).

25. Mallucci, E. Natural disasters, climate change, and sovereign risk. *Journal of International Economics* **139**, 103672 (2022).

26. Cheng, J. & Chang, S. Rare disasters, local currency-denominated external debt and sovereign default risk. *Economics Letters* **250**, 112313 (2025).

27. Chamon, M., Klok, E., Thakoor, V. & Zettelmeyer, J. An Economic Analysis of Debt-for-Climate Swaps. *IMF Econ Rev* **72**, 918–939 (2024).

28. Nedopil, C., Yue, M. & Hughes, A. C. Are debt-for-nature swaps scalable: Which nature, how much debt, and who pays? *Ambio* **53**, 63–78 (2024).

29. Pacelli, V., Foglia, M. & Mariano, D. The link between climate and systemic risk: A bibliometric and systematic literature review. *Research in International Business and Finance* **79**, 103072 (2025).

30. Saxena, K. & Singh, M. Investors reward countries for participating in climate agreements. *Nat Commun* **15**, 8908 (2024).

31. Seghini, C. & Dees, S. The green transition and public finances. *Macroecon. Dynam.* **29**, e152 (2025).

32. Dibley, A., Wetzer, T. & Hepburn, C. National COVID debts: climate change imperils countries' ability to repay. *Nature* **592**, 184–187 (2021).

33. Aligishiev, Z., Massetti, E. & Bellon, M. Macro-fiscal implications of adaptation to climate change. *IMF Staff Climate Notes* **2022**, (2022).

34. Giovanis, E. & Ozdamar, O. The impact of climate change on budget balances and debt in the Middle East and North Africa (MENA) region. *Climatic Change* **172**, 34 (2022).

35. Mallucci, E. Natural disasters, climate change, and sovereign risk. *Journal of International Economics* **139**, 103672 (2022).

36. Beirne, J., Renzhi, N. & Volz, U. Feeling the heat: Climate risks and the cost of sovereign borrowing. *International Review of Economics & Finance* **76**, 920–936 (2021).

37. Battiston, S. & Monasterolo, I. A Climate Risk Assessment of Sovereign Bonds' Portfolio. *SSRN Journal* https://doi.org/10.2139/ssrn.3376218 (2019) doi:10.2139/ssrn.3376218.

38. Monasterolo, I. Climate Change and the Financial System. *Annu. Rev. Resour. Econ.* **12**, 299–320 (2020).

39. Bolton, P., Despres, M., da Silva, L. A. P., Samama, F. & Svartzman, R. *The Green Swan*. vol. None (Bank for International Settlements, 2020).

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