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RETHINKING CLIMATE CHANGE VULNERABILITY ASSESSMENT: A UNIFIED FRAMEWORK FOR CLIMATE POLICY AND CLIMATE FINANCE

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ABSTRACT----------
This study develops an analytical framework for climate vulnerability assessment that brings climate policy and climate finance into a single perspective: finance is the input, the mitigation and adaptation policies it underwrites are the mechanism, and reduced vulnerability and improved welfare in developing countries are the outcome. The contribution of this paper is threefold. First, it synthesises the IPCC SREX risk framework (2012) and the Füssel and Klein adaptation policy assessment framework (2006), into one representation holding climatic and non-climatic spheres, inherent vulnerability, and policy response space. Second, it inserts climate finance as an explicit element, distinguishing mitigation finance, adaptation finance, and loss-and-damage facility, and maps each onto a policy capacity. Third, by tracing the full chain from emissions through hazard, vulnerability, policy, and finance to impact, it supplies a testable logic: finance builds capacity, capacity improves climate performance, and improved performance reduces vulnerability.

KEYWORDS: *Climate Change Vulnerability, Climate Policy, Mitigation, Adaptation, Climate Finance, Climate Impact Assessment, Hazard.*----------

1. INTRODUCTION

Anthropogenic greenhouse gas (GHG) emissions have made extreme weather events more frequent and intense, inflicting widespread and sometimes irreversible harm on natural and human systems while magnifying existing inequalities. Because emitters do not pay for this wider damage, economists treat human-induced climate change as a negative externality, and the greatest market failure ever seen (Stern, 2007). Historical responsibility lies overwhelmingly with the early-industrialising economies of the United States and the European Union, together roughly 37 per cent of cumulative global emissions (Ritchie & Roser, 2020; World Resources Institute [WRI], 2023), yet the heaviest burdens fall on developing countries that contributed least, raising enduring concerns of climate justice. The UNFCCC enshrines the principle of "common but differentiated responsibilities and respective capabilities," obliging developed countries to assist developing ones in mitigation and adaptation (UNFCCC, 1992); its clearest expression is the finance commitment made at Copenhagen in 2009 and reaffirmed under the Paris Agreement, pledging USD 100 billion per year by 2020, succeeded at COP29 in Baku in 2024 by the New Collective Quantified Goal of USD 300 billion per year by 2035.

The scale of these pledges makes it essential to ask whether the finance mobilised has reduced vulnerability in recipient countries. The question opens onto three vantage points: climate finance is the *input*; the policies it underwrites are the *mechanism* translating resources into action; and reduced vulnerability, alongside improved welfare, is the *outcome*. Yet vulnerability is itself a contested, multidimensional construct, understood as susceptibility to harm from exposure to climatic stresses and a limited capacity to adapt (Adger, 2006). Linking it to the upstream domains of finance and policy requires a scaffolding capable of holding all three within a single frame.

This study builds that scaffolding by integrating two canonical frameworks. The first is the IPCC SREX (2012), which introduced the hazard–exposure–vulnerability conception of risk that AR5 (2014) and AR6 (2021) carried forward. The second is the Adaptation Policy Assessment of Füssel and Klein (2006), building on the earlier IPCC lineage of the Third Assessment Report (2001) and AR4 (2007) and on the determinants of vulnerability in the disaster-risk and measurement literature (Birkmann, 2013): exposure, susceptibility (sensitivity), and a lack of resilience comprising a lack of coping and adaptive capacity. The synthesis is then extended by inserting climate finance, which none of the source frameworks contains.

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The choice rests on complementarity. SREX gives the most rigorous account of how a hazard combines with exposure and vulnerability to generate disaster risk; it decomposes inherent vulnerability into susceptibility and a lack of capacities, locates disaster risk management in the response space, and accommodates residual harm (Cardona et al., 2012; IPCC, 2012). What it does not do is articulate policy in terms of distinct mitigative and adaptive capacities, which is the strength of Füssel and Klein, treating mitigation and adaptation symmetrically. The two are halves of one picture to complete. Other approaches like Social-constructivist accounts, the Pressure-and-Release model of Blaikie, Cannon, Davis, and Wisner (1994; revised in Wisner, Blaikie, Cannon, & Davis, 2004) and the entitlements account of Adger and Kelly (1999), and indicator frameworks such as Cutter, Boruff, and Shirley's (2003) Social Vulnerability Index, do illuminate the determinants of vulnerability but fail to trace the causal pathway from policy and finance to outcome.

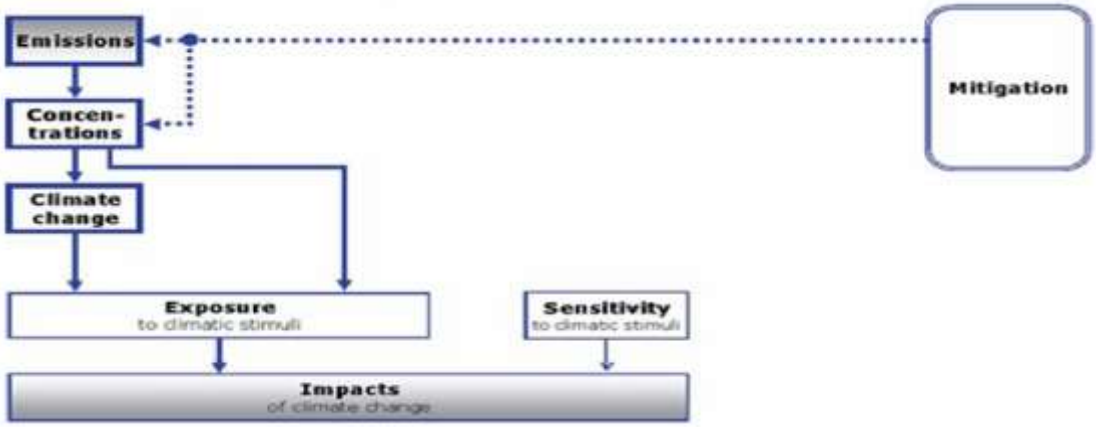
The paper proceeds as follows. Section 2 shows how impact assessments became vulnerability assessments; Section 3 sets out the three schools of thought and why the IPCC-aligned school is the one this study builds on; Section 4 presents the two foundational frameworks, SREX (4.1) and Füssel and Klein (4.2); Section 5 constructs the integrated framework; and Section 6 concludes.

2. CLIMATE CHANGE IMPACT ASSESSMENT

Climate change threatens natural and human systems through rising sea levels, biodiversity loss, and, in the extreme, species extinction (Arias et al., 2021). The question is how to measure such impacts. Climate impact assessment estimates the effects of a climate-change scenario against a hypothetical constant-climate baseline (Füssel & Klein, 2006, p. 312); over time it evolved into vulnerability assessment, extending the analysis to how susceptible systems are and how far they can adapt. Figure 1 presents the traditional impact-assessment framework, from anthropogenic emissions to GHG concentrations and climate change, with mitigation curtailing emissions and enhancing sinks. Below, we explain the concepts used in this framework.

Vulnerability is the "characteristics and circumstances" of people "that make [them] susceptible to the damaging effects of a hazard" (UNDRR, 2009, p. 30): built-in susceptibility from structural, socio-economic, or biophysical conditions, independent of any specific hazard.

Figure 1: Conceptual Framework of a Traditional Climate Change Impact Assessment



Source: Füssel & Klein, 2006, Figure 3.

Exposure is a spatial concept, the proximity of a vulnerable community to a hazard (IPCC, 2014a, p. 1765), characterised by frequency, magnitude, and duration and determined by the level of climate change and the system's location (Füssel & Klein, 2006). *Sensitivity (susceptibility)* is internal, the degree to which a system is affected by exposure, directly or indirectly (IPCC, 2001a, p. 993), conditioned by human endowments (population, institutions, economic structures) and environmental ones (soils, water, ecosystems).

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Resilience, alongside vulnerability, is central to the global-environmental-change literature: the ability of a system to cope with hazards and return to its pre-disaster state, including improving preparedness and speeding recovery (Kohlitz et al., 2017). The Hyogo Framework ties it to how far a social system can organise itself to learn from past disasters (UNDRR, 2005, p. 4), and Sustainable Development Goal 13.1 calls for strengthening it in all countries. *Adaptive capacity* is the long-term ability to build resilience and adjust to climate risks (IPCC, 2014a, p. 1758), depending on access to financial, technical, educational, and community resources; greater adaptive capacity yields greater resilience and reduces sensitivity. *Coping capacity* is the short-term ability to absorb, manage, and recover from immediate shocks; where it is low, losses are amplified even when exposure and sensitivity are unchanged.

These concepts are interrelated: adaptive capacity covers human capabilities, while resilience describes the dynamic state of the whole social-ecological system, which deploys coping capacity to absorb the shock, adaptive capacity to adjust, and recovers stronger. High vulnerability results from high exposure and sensitivity together with low adaptive and coping capacities.

3. SCHOOLS OF THOUGHT ON VULNERABILITY ASSESSMENT

Three major schools stand out: geographic development and poverty research; hazard and disaster-risk-reduction research; and climate-change science, particularly adaptation research (Birkmann, 2013, p. 12; Mohan, 2025).
(a) Geographic development and poverty research. Arising in the 1970s from debates on the roots of famine, this school pitted the food-availability-decline thesis against the food-entitlement account of Sen (1981). Later work on coping strategies stressed social and psychological losses (Davies, 1996), while Watts and Bohle (1993, p. 46) cast vulnerability as a multidimensional social space defined by political, economic, and institutional factors.

(b) Hazard and disaster-risk-reduction research. Emerging in the 1980s after the UNDRO Commission (1980) and the work of Burton et al. (1978), Hewitt (1983), and Susman et al. (1983), this school's first-generation "risk-hazard" view took a physical-science perspective, treating vulnerability as a dose-response relationship between an exogenous hazard and its effects (Dilley & Boudreau, 2001), rather than as a facet of the human world. The impetus to *socialise* disasters came from O'Keefe et al. (1976, p. 566), who held disasters to be repercussions of social, economic, and political factors more than *natural* ones; Burton et al. (1978) and Hewitt (1983, p. 10) faulted UN studies for ignoring human–environment relations, and Susman et al. (1983, p. 264) defined disaster as the interface between an extreme physical event and a vulnerable human population. This ushered in the second-generation, social-constructivist paradigm, treating vulnerability as an *a priori* condition set by socio-economic and political factors (Wisner et al., 1994; Adger & Kelly, 1999).

The paradigm produced several models. Foundational risk-hazard models assess a hazard's impact as a function of exposure and dose-response sensitivity (Burton et al., 1978) but ignore differential exposures and the social structures producing them (Wisner et al., 1994). This yielded the Pressure and Release (PAR) model (Wisner et al., 1994, p. 46), which frames disaster as the intersection of the processes generating vulnerability on one side and the natural hazard on the other, likened to a nutcracker, with "release" requiring that pressure be relieved back to its root causes. Because the original PAR is static and does not link exposure directly to susceptibility, Wisner et al. (1994, pp. 79–80) added an Access model concerned with people's access to the assets and opportunities that let them reduce vulnerability. Cutter (1996) then developed an integrative "hazards-of-place" model in which a geographic filter and social fabric moderate hazard potential to produce overall place vulnerability (Cutter et al., 2003, p. 243), on which the widely used Social Vulnerability Index rests.

(c) Climate-change science and adaptation research. Arising within IPCC Working Group II (IPCC, 2012), this school initially focused on mitigation, treating adaptation as minor (IPCC, 1990), before shifting to adaptation and vulnerability reduction from AR4. AR4's definition of vulnerability as the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change (IPCC, 2007a, p. 883) remained structured by the impact-oriented first-generation view (Füssel & Klein, 2006, p. 322) and was later judged questionable (Birkmann, 2013, p. 60). The 2012 special report offered a self-critique, recognising the social-vulnerability paradigm and conceding that physical forces had dominated the earlier definition while the social environment was reduced to sensitivity and adaptive capacity. Vulnerability is now treated as independent of physical forces (IPCC, 2012, p. 33): extreme events do not by themselves produce disasters; disaster risk arises only when they strike people and property that are exposed and inherently vulnerable.

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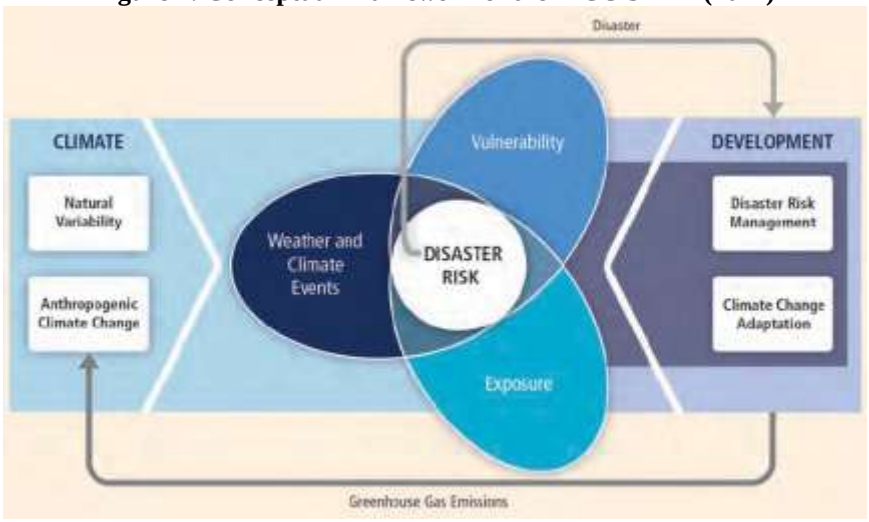
4. TWO FOUNDATIONAL FRAMEWORKS FOR AN INTEGRATED ASSESSMENT

Both frameworks belong to the fourth, integrated school. SREX comes first, for the risk-generating logic and the anatomy of vulnerability; Füssel and Klein second, for the response architecture into which we add the component of climate finance later.

4.1 The IPCC SREX Framework

The 2012 IPCC Special Report bridged two communities that had worked apart: disaster risk reduction and climate-change adaptation. Its central proposition is that disaster risk arises not from a hazard alone but from the interaction of three components, the physical weather and climate events, the exposure of people and assets, and the vulnerability of what is exposed (IPCC, 2012). Risk is the *product*, not the sum, so reducing any one component reduces risk. SREX places these components between two driving spheres: the climate, whose extremes are shaped by natural variability and anthropogenic change driven by emissions, and development, the socio-economic processes determining exposure and vulnerability; their interaction constitutes disaster risk, whose materialisation is a disaster (IPCC, 2012, Figure SPM.1). By putting the climatic and non-climatic on an equal footing, it makes climate-related harm the co-product of physical and developmental forces, the dual-sphere structure the integrated framework inherits.

Figure 2: Conceptual Framework of the IPCC SREX (2012)



Source: IPCC, 2012 (Figure SPM.1, p. 4).

SREX's definitions are adopted here with minor adaptation., as have explained earlier. However, two features matter. First, vulnerability is defined independently of the physical event, so that, unlike the earlier IPCC definition which folded the stimulus into vulnerability, it retains its power to expose the social construction of risk (Birkmann, 2013). Second, exposure and vulnerability, unlike the hazard, can be influenced by policy in the short to medium term and vary with social, institutional, and environmental factors (Cardona et al., 2012); being produced by socio-economic processes, they can be reduced by acting on those processes.

On the response side, SREX positions two levers, disaster risk management and climate-change adaptation, supported by the goal of resilience; both can act on any component and can include risk-transfer instruments such as insurance for residual risk. The explicit disaster-risk-management function is one reason SREX was chosen: it gives a natural home to that element of the policy block, and its treatment of residual risk anticipates the loss-and-damage dimension the finance block adds. Cardona et al. (2012) identify two recurring causal factors, susceptibility and a lack of resilience: vulnerability is high where systems are both highly susceptible and poorly endowed with capacities to cope and adapt. The two capacities differ: coping is *ex post*, using available resources during and after a hazard, whereas adaptation is *ex ante*, transforming structures over the longer term through learning and structural change (Birkmann, 2013). SREX is also careful about the limits of management: some harm is residual, and at high levels of change the limits to adaptation must be confronted. What it lacks is an account of how policy converts resources into capacity and capacity into harm reduction, which the second framework supplies.

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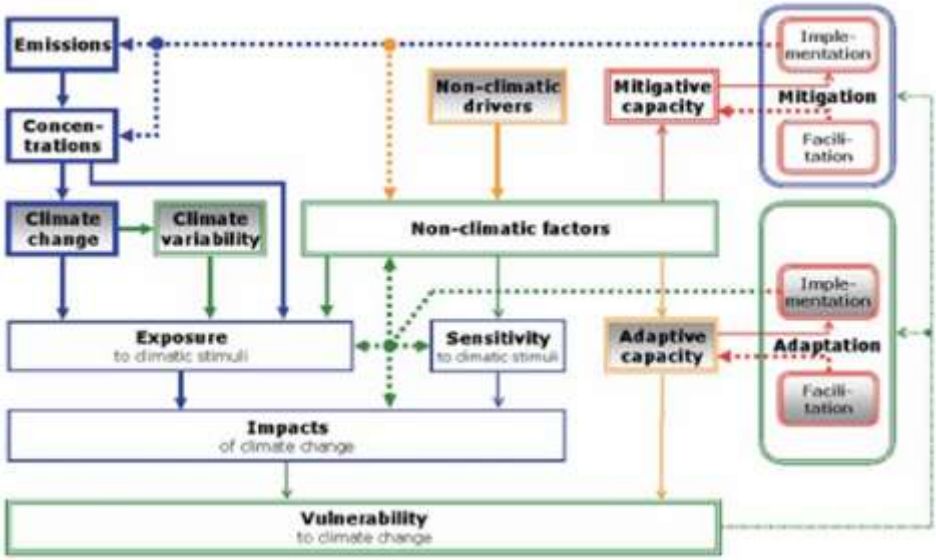
4.2 The Adaptation Policy Assessment of Füssel and Klein

The adaptation policy assessment of Füssel and Klein (2006) is the culmination of the four-stage evolution of vulnerability assessment, the stage at which analysis turns toward policy. Where earlier stages describe risk, this one recommends action, identifying which measures a region or sector needs and how they can be developed, applied, and funded (Füssel & Klein, 2006; Burton et al., 2002). Because this study concerns the funding of adaptation and mitigation, it is especially significant: it is the only stage placing funding and implementation at the centre. Structurally, it retains the full causal chain, emissions and concentrations driving change, which with exposure and sensitivity produce impacts, and impacts with adaptive capacity determine vulnerability, embedded within a field of non-climatic drivers (demographic, economic, technological) and factors (economic diversification, education, social networks) that shape sensitivity, the same integration of climatic and non-climatic that SREX achieves, approached from the policy side (IPCC, 2012).

Figure 3: The Füssel and Klein Framework (2006)



Source: Füssel & Klein, 2006 (Figure 6).

The distinctive contribution of this framework is a symmetric account of capacity and policy. Mitigation and adaptation are parallel options, each organised around a capacity. *Adaptive capacity* is the ability to adjust to climate change, moderate damages, and exploit opportunities, its determinants being non-climatic factors such as economic resources, technology, skills, infrastructure, institutions, and equity (Brooks, 2003; Smit & Pilifosova, 2001). *Mitigative capacity* is the symmetric ability to reduce emissions, depending on institutions, resources, and technology (Yohe, 2001). Placing the two side by side matters because climate finance is itself divided into mitigation and adaptation streams, each intelligible only against the capacity it builds. Within each capacity, *facilitation* enhances capacity through research, data, awareness raising, and institution-building, while *implementation* reduces harm through concrete measures such as flood defences, early-warning systems, or replacing carbon-intensive infrastructure. The relationship is recursive: adaptive capacity determines the feasibility of implementation, while facilitation builds that capacity (Füssel & Klein, 2006). This is precisely how climate finance works, funding facilitation that builds capacity and implementation that reduces exposure and sensitivity.

The inputs and outputs also change (Füssel & Klein, 2006): where impact and vulnerability assessment take a climate scenario as input and an estimate of harm as output, adaptation policy assessment broadens the inputs to include climate variability, non-climatic drivers, and current adaptive capacity, and yields recommended strategies rather than projected harm. Assessment is thus reoriented from prediction to prescription, the "Type 2" adaptation research of Burton et al. (2002) that begins from current vulnerability, which is indispensable for a study of effectiveness, since effectiveness is a property of measures actually implemented, not of harms merely projected. The two frameworks are thus complementary: SREX tells us how vulnerability becomes harm, Füssel and Klein how policy and capacity

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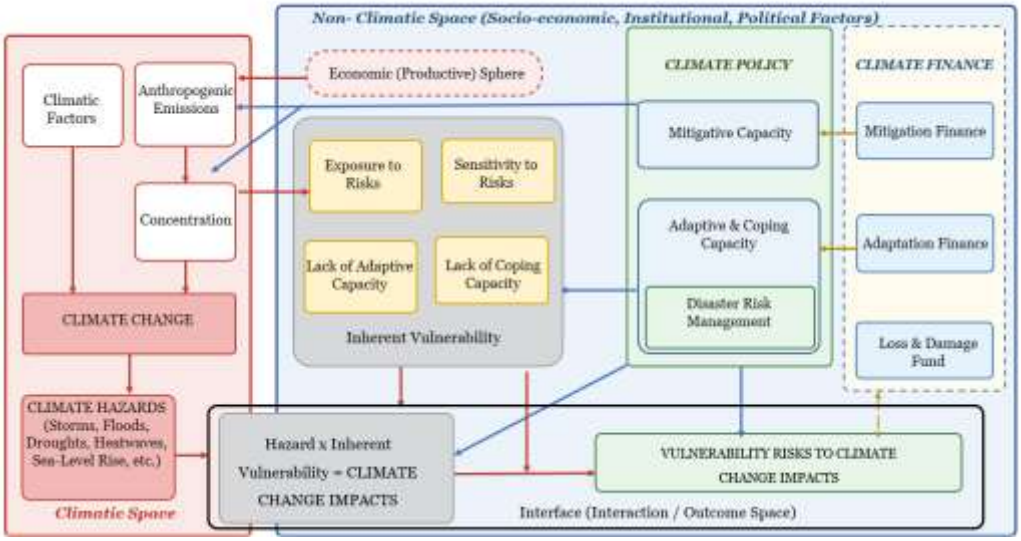
prevent it (Cardona et al., 2012; IPCC, 2012). Neither, however, names the resource that funds the capacities or the channels through which it flows; this we develop in the next section.

5. DEVELOPING THE INTEGRATED CONCEPTUAL FRAMEWORK

The integrated framework (Figure 4) weaves SREX (2012) and Füssel and Klein (2006) together and extends them by inserting climate finance explicitly. It divides the analysis into three spaces: to the left, the *climatic space*, the domain of physical processes inherited from the SREX climate sphere and the Füssel and Klein impact chain; to the right, the *non-climatic space*, the domain of socio-economic, institutional, and political factors, within which inherent vulnerability, the climate-policy response, and the climate-finance flows are located; and between them, at the foot of the diagram, the *interface*, the outcome arena in which the two meet and harm is realised.

The climatic space reproduces the chain from human activity to physical hazard: emissions raise GHG concentrations; concentrations drive climate change; and change manifests as a spectrum of hazards, storms, floods, droughts, heatwaves, sea-level rise, terminating in the hazard term that feeds the outcome space. Mitigation ultimately acts here, since any reduction in emissions propagates downstream to attenuate change and its hazards.

Figure 4: The Integrated Climate Vulnerability Assessment Framework Unifying Climate Policy and Climate Finance



The non-climatic space contains the social machinery of vulnerability and response, in three blocks. The first is the *inherent-vulnerability block*. Older frameworks, such as the IPCC Third Assessment Report, often collapsed the physical hazard and local socio-economic weaknesses into a single vulnerability score, obscuring whether a region was at risk from worsening weather or from poor local development. SREX instead treats vulnerability as an inherent, pre-existing state independent of the hazard, letting the framework isolate physical hazards (changing precipitation) from human variables (housing quality) and clarifying that a hazard becomes a disaster only when it meets an exposed and vulnerable population (IPCC, 2012). Following SREX and its disaggregation in Birkmann (2013), inherent vulnerability resolves into four components: exposure, sensitivity, a lack of adaptive capacity, and a lack of coping capacity, all conditioned by the non-climatic factors of the Füssel and Klein framework.

The second is the *climate-policy block*, drawn from the response architecture of Füssel and Klein and the disaster-risk-management function of SREX. It comprises mitigative capacity, adaptive and coping capacity, and disaster risk management. Mitigative capacity acts back on the climatic space, attenuating emissions and hence the hazard; adaptive and coping capacity, with disaster risk management, act on the inherent-vulnerability block, reducing the lack of capacities and, through implementation, lowering exposure and sensitivity. The policy block is thus the hinge where deliberate human response engages both the hazard chain and the social vulnerability of exposed systems.

The third, and the original contribution, is the *climate-finance block*. In both source frameworks the resource that funds capacities is implicit; this study makes it explicit and disaggregates it into three channels mirroring the international architecture of climate finance, mitigation finance, adaptation finance, and a loss-and-damage facility, understood as resources provided by developed to developing countries in line with climate justice. Mitigation finance flows to mitigative capacity, strengthening the ability to reduce emissions and, through the policy block's feedback, attenuating the hazard. Adaptation finance flows to adaptive and coping capacity and to disaster risk management, strengthening the capacities that reduce inherent vulnerability. The loss-and-damage facility connects to the outcome space, addressing the residual risk that mitigation and adaptation cannot prevent, the finance-side counterpart of the residual harm SREX acknowledges. Each channel maps onto a capacity, each capacity onto a determinant of hazard or vulnerability, and each determinant onto the harm that materialises in the outcome space.

The interface expresses the central relationship. Following the SREX proposition that risk emerges from the interaction of hazard and vulnerability, it combines the hazard from the climatic space with the inherent vulnerability from the non-climatic space: hazard multiplied by inherent vulnerability yields climate-change impacts, which, with the system's residual capacities, constitute the vulnerability risk the loss-and-damage facility is designed to address. The multiplicative form is not incidental; it encodes the SREX insight that hazard and vulnerability are interacting factors, so that reducing either reduces the product, and a high hazard meeting a low vulnerability need not produce catastrophe.

Read as a whole, the framework lays out the logic that motivates future empirical work: finance strengthens the capacities in the policy block, which in turn attenuate the hazard and reduce inherent vulnerability, so that the combined effect, registered in the interface, is a reduction in impacts and residual vulnerability risk. The framework deliberately leaves aside temporal dynamics, cross-scale relationships, the uncertainty of projections, and the political economy of how finance is allocated; these omissions are the price of clarity.

6. CONCLUSION

This study set out to develop a conceptual framework capable of scaffolding empirical analysis of climate-finance effectiveness. It retraced the evolution of vulnerability analysis, from linear impact assessments concerned only with biophysical damage, through vulnerability assessments that progressively admitted non-climatic factors and the capacity to adapt, to the adaptation policy assessment that turned the enterprise toward prescription, and explained why it builds on the third, IPCC-aligned school while drawing on the others for the internal anatomy of vulnerability. From that school it examined two complementary frameworks: SREX, which supplies the generative logic of risk, a disaggregated and dynamic conception of vulnerability, a disaster-risk-management function, and the treatment of residual harm; and Füssel and Klein, which supplies the response architecture of symmetric mitigative and adaptive capacities and the recursive facilitation and implementation activities through which capacity is built and harm reduced.

The integrated framework binds the two together and extends them by inserting climate finance as a distinct block of three channels: mitigation finance, adaptation finance, and a loss-and-damage facility. By mapping each channel onto a capacity, each capacity onto a determinant of the hazard chain or of inherent vulnerability, and each determinant onto the harm realised in the interface, it makes visible the full pathway from the provision of finance to the reduction of vulnerability through improved climate performance, and supplies the testable logic on which empirical analysis can build.

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