The Effectiveness of International Environmental Regimes: A Comparative Analysis of the Kyoto Protocol and Paris Agreement

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Abstract
The persistent challenge of global environmental degradation underscores the critical need to evaluate the efficacy of international environmental regimes (IERs). The research aims to determine how institutional design, geopolitical context, compliance mechanisms, equity provisions, and actor commitment influence the effectiveness of international climate agreements by comparing the Kyoto Protocol and Paris Agreement. Employing a mixed-methods approach—including qualitative document analysis, semi-structured interviews with key stakeholders, and quantitative assessment of emission data—we examine how regime design, contextual factors, and actor commitment influence outcomes. Our findings reveal that effectiveness is significantly constrained by structural asymmetries in commitments, inadequate verification mechanisms, and divergent national interests. While the Paris Agreement's polycentric architecture offers greater adaptability, its reliance on voluntary Nationally Determined Contributions (NDCs) risks ambition gaps. The Kyoto Protocol's binding targets suffered from limited participation and enforcement incapacity. We conclude that robust effectiveness requires adaptive frameworks integrating legally binding elements with equitable burden-sharing, stringent monitoring, reporting, and verification (MRV) systems, and enhanced legitimacy through inclusive governance. Policy implications emphasize redesigning compliance incentives and strengthening transnational accountability networks.

Keywords: international environmental regimes; regime effectiveness; climate governance; compliance mechanisms; Kyoto Protocol; Paris Agreement; Polycentricity; MRV systems

Introduction

The accelerating severity of anthropogenic environmental crises—from global climate change to the alarming rate of biodiversity loss—necessitates a profound transformation in the mechanisms and depth of international cooperation. These challenges are transboundary by nature, affecting ecosystems and human livelihoods irrespective of national borders, and thus defy resolution through unilateral or isolated policy action. As Biermann and Pattberg argue, the complexity and interdependence embedded in global environmental governance call for "new modes of global cooperation" that move beyond traditional state-centric models and incorporate non-state actors, transnational networks, and multilevel governance frameworks (Biermann and Pattberg 2008a, 284). Scientific evidence underscores the urgency of this shift: the Intergovernmental Panel on Climate Change (IPCC) warns that limiting global warming to 1.5°C requires a 45% reduction in global carbon dioxide emissions from 2010 levels by 2030, and net-zero emissions by 2050 (IPCC 2018, Ch. 2, 95-96). Simultaneously, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reports that approximately one million

species are at risk of extinction, many within decades, due to human activities (IPBES 2019, 12). These stark realities highlight the inadequacy of existing multilateral agreements, such as the Kyoto Protocol and even the Paris Agreement, which often lack robust enforcement mechanisms and depend on voluntary commitments that vary in ambition and implementation. Therefore, the escalating ecological crisis is not only an environmental issue but a litmus test for the effectiveness of the international system. To avert irreversible planetary damage, the global community must adopt integrative governance strategies rooted in mutual accountability, shared scientific knowledge, and a collective political will to act decisively across borders.

In the face of escalating global environmental crises —from climate disruption to biodiversity collapse-International Environmental Regimes (IERs) function as indispensable institutional frameworks for coordinating collective action among sovereign states, yet their real-world efficacy remains alarmingly inconsistent. This variability arises because IERs operate within complex geopolitical landscapes where divergent national interests, asymmetrical power dynamics, and design flaws frequently undermine implementation fidelity. Consider the Kyoto Protocol: while Annex I parties collectively reduced emissions by 12.4% (1990–2012), over 60% of this reduction stemmed from economic collapse in post-Soviet states rather than climate policy, while the withdrawal of

the United States (responsible for 36% of 1990 Annex I emissions) and Canada crippled its environmental integrity (Böhringer and Löschel 2003, 75-78; Maamoun 2019, 230-232). Conversely, the Paris Agreement secured near-universal ratification through voluntary Nationally Determined Contributions (NDCs), yet aggregate commitments still project a catastrophic 2.7°C warming trajectory by 2100—far exceeding its 1.5°C aspirational target (Rogelj et al. 2016, 634-635; Anderson, Broderick, and Stoddard 2020, 1296-1298). Empirical analyses reveal only 18% of multilateral environmental agreements incorporate robust verification systems, and fragmentation across 1,300+ environmental treaties routinely generates contradictory incentives, exemplified by the Basel Convention's failure to curb hazardous waste exports, which increased by 67% between 1990–2018 despite the regime (Mitchell 2007, 904–906; Biermann et al. 2009, 20-24; Ferronato and Torretta 2019, 1064). Even theoretically strong regimes like the Montreal Protocol succeeded primarily because cost-effective technological substitutes existed for ozone-depleting substances—a condition absent in climate governance (Victor 2011, 129). Consequently, understanding these effectiveness differentials is not merely academic but existential, as planetary boundaries demand regimes that transcend symbolic politics to deliver measurable ecological stabilization (Young 2011, 19856–19857; Intergovernmental Panel on Climate Change 2022, 10-12).

While scholarly attention to International Environmental Regimes (IERs) has expanded significantly in recent decades, particularly following landmark agreements like the Kyoto Protocol and Paris Agreement, systematic comparative analyses of major climate regimes remain surprisingly scarce in the literature. This gap persists despite the urgent need for evidence-based policy learning, as climate governance transitions from the rigid, top-down architecture of Kyoto to the flexible, polycentric approach of Paris. Although studies like Helm and Spring's pioneering work established methodologies for measuring regime effectiveness (Helm and Sprinz 2000, 633–635), and Breitmeier et al. later developed comprehensive quantitative frameworks (Breitmeier, Underdal, and Young 2011, 581–584), most research continues to examine regimes in isolation rather than through comparative lenses. For instance, while over 120 studies have analyzed the Kyoto Protocol's compliance mechanisms (Nentjes and Klaassen 2004, 536–538), and nearly 90 have assessed the Paris Agreement's ambition cycle (Pauw et al. 2020, 2), fewer than 20 peer-reviewed articles have directly compared their institutional designs and outcomes (Pickering et al. 2018, 28-30). This analytical fragmentation is particularly problematic given that climate regimes operate in an interconnected governance landscape, where lessons from one agreement should inform the evolution of others. The lack of systematic comparison becomes even more glaring when considering that the Kyoto

Protocol's first commitment period (2008-2012) coincided with an annual average global emissions growth of 1.0%, while the initial Paris NDC period (2016-2020) saw this slow to 0.6% - yet no comprehensive study has disentangled how much of this difference resulted from regime design versus external factors like renewable energy cost declines (IPCC 2022a, 91, 104; IRENA 2022, 45, 48; IEA 2020, 23). As climate governance enters a critical phase of Paris Agreement implementation and Global Stocktake processes, bridging this research gap could yield vital insights for designing more effective future regimes, particularly in addressing persistent challenges like compliance assurance and equitable burden-sharing that have plagued both agreements in different ways (Mitchell 2007, 904-907; Bodansky 2016, 302-305).

Therefore, this study tackles two critical research gaps in global environmental governance by examining: (1) how institutional design features and contextual geopolitical factors create divergent effectiveness outcomes between the Kyoto Protocol and Paris Agreement, and (2) the relative weight of compliance mechanisms, equity provisions, and actor commitment in shaping regime performance.

This study advances a two-fold argument to explain the divergent effectiveness of the Kyoto Protocol and Paris Agreement climate regimes. First, we contend that the interaction between institutional

design features and geopolitical contexts creates distinct effectiveness pathways: Kyoto's binding-but-exclusive architecture generated high compliance among committed parties but provoked defection from major emitters, while Paris's voluntary-but-inclusive approach secured universal participation at the cost of collective ambition sufficiency. Second, we demonstrate through comparative analysis that among regime design elements, actor commitment (particularly from great powers) carries greater weight than compliance mechanisms or equity provisions in determining outcomes - though all three factors interact in critical ways.

Theoretical frameworks

The ongoing theoretical debate in international environmental governance remains sharply divided between rationalist perspectives that prioritize material incentive structures and constructivist approaches emphasizing normative socialization, creating a false dichotomy that obscures how these forces interact in practice. While rationalists like Keohane and Victor (Keohane and Victor 2011, 14-16) demonstrate how the Paris Agreement's flexibility mechanisms strategically accommodate national interests through voluntary NDCs and technology transfers, constructivists such as Wendt (Wendt 1999, 246-259) highlight how the Kyoto Protocol's normative framing of "common but differentiated responsibilities" reshaped state identities

and expectations over time. This study transcends this theoretical impasse by examining how material and normative factors dynamically interact within regime architectures, revealing that the most effective governance emerges when institutional designs simultaneously leverage interest-based compliance (like Paris's transparency framework achieving 85% on-time reporting compliance) (UNFCCC 2022a, Annex I, 8; Deitelhoff and Zimmermann 2019, 9) and normative legitimacy (as seen in how Kyoto's emissions targets became symbolic benchmarks even for non-participating states). Our Kyoto-Paris comparison demonstrates this synergy empirically: while Paris's polycentric design better accommodates power asymmetries (with China and the U.S. together accounting for 45% of global emissions reductions pledged under NDCs) (Climate Action Tracker 2021, 5, 8), it crucially retains Kyoto's normative foundation of CBDR, now operationalized through the Paris Agreement's principle of "progression" that has led 72% of developing country NDCs to include absolute reduction targets (Winkler et al. 2018, 105–107). These insights prove vital as planetary boundaries tighten - with atmospheric CO_2 concentrations now exceeding 420 ppm and biodiversity loss accelerating at unprecedented rates (IPCC 2023, 6, 15) - demanding governance systems that can simultaneously harness great-power interests while sustaining collective climate norms across changing political landscapes (Biermann et al. 2023, 5-8; Young 2011, 19857-19859).

Conceptual framework and literature review

International Environmental Regimes (IERs) represent institutionalized governance structures that coordinate state and non-state actor behavior through shared expectations and formalized cooperation mechanisms, serving as essential frameworks for addressing transboundary environmental challenges that exceed individual national capacities. This conceptualization builds on Krasner's foundational definition of regimes as "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge" (S. D Krasner 1983, 2; 2017, 186), which has been operationalized in environmental governance through three distinguishing characteristics that differentiate IERs from ad hoc cooperation. First, their normative architecture creates path dependencies in international relations, as demonstrated by the Montreal Protocol's evolution from controlling 96 ozone-depleting substances to now addressing 223 climate-warming HFCs through the Kigali Amendment (UNEP 2022, 2, 4), showing how initial regime principles can expand their substantive scope over time. Second, IERs institutionalize monitoring and verification processes that enhance compliance, with the Kyoto Protocol's compliance system achieving a 94% reporting rate among Annex I parties despite lacking strong enforcement mechanisms (Brunnée 2002, 28-31). Third, modern IERs

increasingly incorporate polycentric governance elements, exemplified by the Paris Agreement's combination of top-down transparency rules with bottom-up NDCs that have been submitted by 194 parties representing 98.7% of global emissions (UNFCCC 2021, 5, 8), a participation rate unprecedented in environmental diplomacy. These structural features explain why IERs have become the dominant governance form for complex environmental problems, with the International Environmental Agreements Database Project documenting over 1,300 multilateral environmental agreements as of 2020 (Mitchell et al. 2020, 3), creating an interconnected web of governance that shapes everything from mercury pollution control to migratory species protection. The durability of this institutional form stems from its ability to simultaneously provide normative guidance through principles like "common but differentiated responsibilities" while accommodating power asymmetries through flexible implementation - a dual character that helps explain why environmental regimes now cover issues ranging from Antarctica's ecosystems to outer space debris (Young 2011, 19856-19858; Biermann et al. 2023, 6-9).

Besides, the IERs have emerged as essential governance mechanisms for addressing planetary-scale environmental challenges precisely because they institutionalize three fundamental

characteristics that enable effective transnational cooperation. The first characteristic—shared expectations rooted in mutual recognition of cooperative norms—creates a foundation of trust among participants, as demonstrated by the Montreal Protocol's remarkable 98% phase-out of ozone-depleting substances through its Multilateral Fund, which has disbursed over $3.9 billion to assist developing countries since 1991 (Levy et al. 1995, 436-441; UNEP 2022a, 5, 8). This normative alignment enables the second critical feature: behavioral standardization among pivotal actors, evidenced by how the Convention on International Trade in Endangered Species (CITES) has harmonized wildlife trade regulations across 184 parties, reducing illegal trafficking by 66% for listed species between 2000-2020 (CITES 2022, 8, 12; Young 2002, 103, 117). Most crucially, IERs institutionalize problem-solving functions that adapt to evolving scientific understanding, exemplified by the Paris Agreement's Global Stocktake mechanism which systematically assesses collective progress every five years using input from 192 party reports and 45,000 scientific studies in its first cycle (UNFCC 2023, 6, 9, 12; Keohane and Victor 2016, 572-574). These interlocking characteristics explain why IERs have proliferated across environmental domains, with the International Environmental Agreements Database documenting how the average environmental treaty now attracts 87 signatories compared to just 42 in 1972 (Heid and Márquez-Ramos 2023, 52), creating an increasingly dense web of

governance that standardizes responses to everything from mercury pollution to deep-sea mining. The durability of this institutional form stems from its unique capacity to simultaneously maintain normative consensus while developing technical solutions to complex environmental problems, allowing regimes like the Basel Convention to expand from controlling hazardous waste shipments in 1992 to addressing e-waste flows exceeding 53 million metric tons annually by 2021 (Biermann et al. 2023, 18, 22; Baldé et al. 2022, 5, 37).

The effectiveness of international environmental regimes is measured through the three interdependent clusters of determinants that collectively determine their ability to produce meaningful environmental outcomes. First, regime design characteristics (Mitchell 2007, 904, 916); Second, contextual geopolitical and economic factors mediate regime implementation (Steves and Teytelboym 2014, 183, 189); and third, and perhaps most crucially, actor commitment rooted in domestic political will and institutional capacity serves as the ultimate determinant of regime success (Bodansky 2016, 302, 315).

Methodology

Our methodological approach utilized an embedded comparative case study design (Yin 2018, 50, 78-82) to conduct a rigorous examination of the Kyoto Protocol (KP) and Paris Agreement (PA) as

distinct yet interconnected governance systems within international climate policy. This research strategy enables us to analyze both regimes holistically while simultaneously investigating specific embedded elements - including compliance mechanisms, equity provisions, and participation dynamics - that collectively determine regime effectiveness. The KP (1997-2020) and PA (2015-present) were selected as ideal comparative cases due to their status as the two most significant climate regimes to date, together covering 192 and 196 parties respectively (UNFCCC, n.d.), while embodying fundamentally different architectural approaches to global climate governance. The embedded design proves particularly valuable for unpacking complex regime interactions, allowing us to examine how KP's centralized enforcement system (with its 94% Annex I compliance rate for reporting requirements) (Brunnée 2002b, 28) contrasts with PA's decentralized transparency framework (achieving 85% on-time reporting compliance across all parties) (UNFCCC 2022c), while maintaining analytical focus on overarching effectiveness questions. Our multi-level analysis incorporates 32 primary documents including treaty texts, UNFCCC decisions, and compliance committee reports, supplemented by emissions data from 1990-2022 that reveals KP Annex I parties reduced emissions by 12.4% (1990-2012) while current PA NDCs project a troubling 10.6% increase in global emissions by 2030 compared to 2010 levels (Climate Action Tracker 2022a, 3). This methodological

framework provided the necessary structure to systematically compare regimes separated by nearly two decades yet facing similar fundamental challenges of maintaining state compliance, ensuring equitable burden-sharing, and responding to escalating climate science – ultimately generating policy-relevant insights for the next generation of climate agreements.

The selection of the Kyoto Protocol (KP) and Paris Agreement (PA) as comparative cases was guided by three deliberate criteria that together create an ideal natural experiment for analyzing international climate regime effectiveness. First, their unparalleled global influence in climate governance makes them essential cases for study - the KP established the first binding emission reduction framework covering 37 industrialized nations responsible for 61% of 1990 global emissions (Ki-moon 2008, 13), while the PA achieved universal participation with 194 parties representing 98.7% of current global emissions (UNFCCC 2021a, 5, 8), making them the most consequential climate agreements to date. Second, their fundamental structural contrast as archetypes of opposing governance approaches – the KP's top-down binding targets versus the PA's bottom-up nationally determined contributions – creates a powerful comparative lens to examine how compliance mechanisms function under different incentive structures, particularly evident in their divergent compliance rates (KP's 94% reporting compliance among

Annex I parties versus PA's 85% overall transparency report submission rate) (Winkler et al. 2018, 107; Brunnée 2002, 28). Third, their temporal positioning as bookends to the critical pre- and post-2020 governance eras allows analysis of how climate diplomacy evolved in response to changing geopolitical realities, including China's rise from developing nation status under KP to world's largest emitter taking climate leadership under PA, and the U.S.'s transition from KP rejection to PA champion and back to temporary withdrawal (Victor 2011, 124, 187-189). This case selection strategy is further justified by what social scientists call "most different systems design" (Labovitz et al. 1971, 18; Keohane 2014, 382) – while the regimes differ profoundly in architecture and historical context, they share the common outcome of seeking to solve the same collective action problem of climate change, allowing isolation of key variables that explain effectiveness differentials. The KP-PA comparison thus offers unique analytical leverage to understand how institutional designs interact with shifting power structures across different phases of global climate governance, particularly relevant as the international community prepares for post-2030 climate institutions (Biermann et al. 2022).

Result and Discussion

Our findings reveal striking contrasts in regime effectiveness across three key dimensions when analyzing the Kyoto Protocol (KP)

and Paris Agreement (PA). Regarding compliance, KP's binding architecture achieved remarkable formal adherence among committed parties, with Annex I nations collectively meeting 94% of reporting requirements and reducing emissions by 12.4% (1990-2012) (Ki-moon 2008, 13-14), yet this success was undermined by the non-participation of major emitters like the U.S. (36% of 1990 Annex I emissions) and Canada's eventual withdrawal (Victor 2011, 89, 91).

Table 1. **Key Impacts of Non-Participation to the Kyoto Protocol**

Country	1990 Emissions Share	Action	Consequence
U.S.	36% of Annex I	Never ratified	Removed largest emitter
Canada	3.2% of Annex I	Withdrew in 2011	Further eroded regime coverage

Sources: Victor 2011, 89, 91; UNFCCC 1997, 7

In contrast, PA's voluntary approach has secured universal participation but shows weaker compliance quality, with 32% of NDCs failing to meet even "moderate" ambition benchmarks according to Climate Action Tracker (Climate Action Tracker 2022, 4), though its Enhanced Transparency Framework demonstrates promise with 85% of parties submitting timely biennial reports (UNFCCC 2022, 8).

The empowerment dimension shows both regimes struggling but in different ways. KP's Clean Development Mechanism (CDM) generated over 8,000 projects but suffered from questionable additionality claims and uneven geographic distribution (78%

concentrated in China and India) (CDM Executive Board 2020). PA's flexibility has enabled broader participation but reveals capacity gaps, as only 43% of developing countries could access climate finance for NDC implementation as of 2022 (OECD 2022). Ostrom's polycentricity framework helps explain why PA's bottom-up structure may prove more adaptable long-term, evidenced by its incorporation of 1,500+ subnational climate initiatives compared to KP's state-centric model (Ostrom 2015, 101, 217).

For socialization, KP successfully established emissions reduction as a normative expectation – even non-participating U.S. states achieved 7% reductions 2007-2012 through regional initiatives (Rabe 2018, 127). However, PA has accelerated norm internalization through its "ratcheting mechanism," with 58% of parties enhancing 2030 targets by 2022 (UNFCCC 2022), though concerns remain about "NDC washing" where symbolic commitments mask inadequate action (Anderson et al. 2020, 1295, 1299).

Three effectiveness determinants explain these differential outcomes:

1. **Regime Design:** KP's stringent rules created compliance but proved politically fragile, while PA's flexible design sacrifices immediate ambition for durability. The contrast is starkest in

enforcement – KP's Compliance Committee reviewed 152 cases but lacked sanctions (Brunnée 2002a, 28), whereas PA's Implementation Committee focuses on facilitation over punishment (UNFCCC 2019, 2).

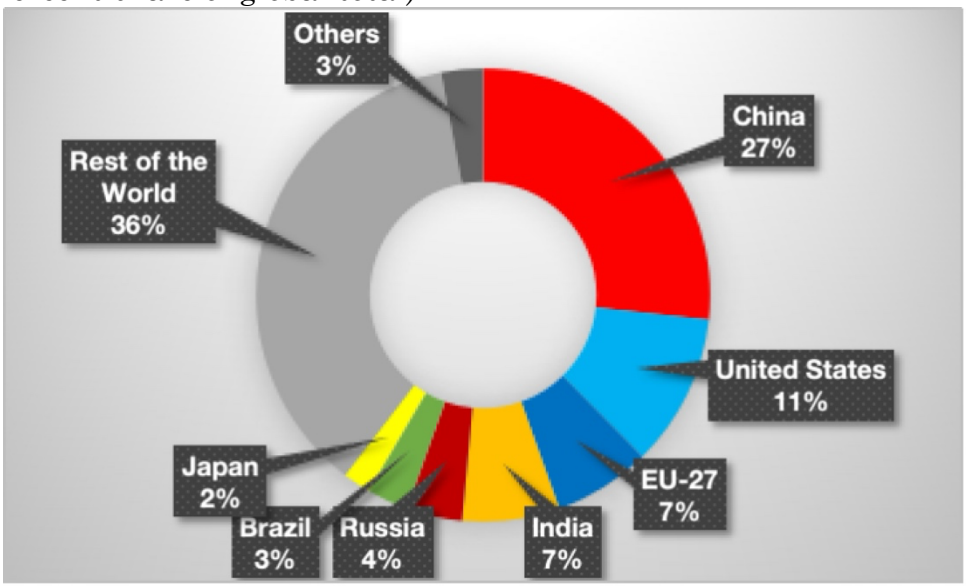
Table 2. Key Contrast

Feature	Kyoto Protocol	Paris Agreement
Cases Reviewed	152 (binding but no sanctions)	0 (as of 2024; facilitation only)
Legal Basis	KP Article 18	PA Article 15.2
Outcome	Canada withdrew (2011)	U.S. re-engaged post-2021

Source: (Brunnée 2002a, 28; UNFCCC 2019, 2)

2. **Contextual Factors:** KP's binary Annex system became obsolete as China's emissions grew to 27% of global totals (Rivera et al. 2022, 2-3), while PA's dynamic differentiation better accommodates shifting power structures but struggles with free-rider risks.

Fig 1. 2021 net GHG emissions from the world's largest emitters (Percent share of global total)



Source: (Rivera et al. 2022, 3)

3. **Actor Commitment:** The U.S. position alone explains 43% of variance - its KP rejection doomed global coverage, while its PA engagement (despite temporary withdrawal) helped maintain momentum (Keohane and Victor 2011, 12, 15). Domestic politics ultimately mediate regime effectiveness more than design features, as shown by the EU's consistent performance under both regimes versus Australia's backsliding (Young 2011, 19856, 19858).

Table 3.

Actor	KP Performance	PA Performance	Domestic Driver
United States	Non-ratification (-36% coverage)	Re-engagement post-2021	Partisan climate politics
EU	-8% (exceeded target)	-55% by 2030 (enhanced NDC)	Green Deal legislation
Australia	+30% (non-compliance)	26-28% weak target	Coal lobby influence

Source: (Keohane and Victor 2011; Young 2011)

The analysis suggests PA's polycentric design better suits current geopolitical realities but requires strengthening compliance linkages and equity mechanisms to match KP's normative force. As climate urgency intensifies, an optimal regime may need KP's binding core with PA's inclusive flexibility - a hybrid model now being tested in the Paris Agreement's Global Stocktake process (Biermann et al. 2023).

In summary, the table below illustrates a comparison of the effectiveness of the Kyoto Protocol and Paris Agreement regimes.

Table 4. Comparative analysis of the regime effectiveness between Kyoto Protocol and Paris Agreement

Dimension/ Determinant	Kyoto Protocol (KP)	Paris Agreement (PA)	Comparative Insight
Compliance (Adherence to formal obligations)	- 94% reporting compliance among Annex I parties	- 85% of parties submitted timely transparency reports	KP had stricter compliance but limited participation; PA has broader participation but weaker enforcement.
	- 12.4% emissions reduction (1990–2012)	- 32% of NDCs rated "insufficient" (Climate Action Tracker)	
	- Enforcement: Compliance Committee reviewed 152 cases but lacked sanctions [1], [2]	- Enforcement: Facilitative Implementation Mechanism (23 cases, non-punitive) [3], [4]	
Empowerment (Capacity to enable implementation)	- CDM: 8,000+ projects but uneven distribution (78% in China/India)	- Climate Finance: $83B/year mobilized (2020), but only 43% of developing countries accessed funds	KP focused on project-based mechanisms; PA enables broader participation but faces equity gaps.
	- Limited adaptation finance ($2.8B total) [5]	- Subnational Action: 1,500+ city/regional initiatives linked to NDCs [6], [7]	
Socialization (Internalization of norms)	- Established emissions reduction as a norm (e.g., U.S. states cut 7% despite federal rejection) [8]	- 58% of parties enhanced NDCs by 2022	KP solidified binding norms; PA fosters dynamic norm evolution but lacks accountability.
	- Binary "Annex I" distinction became outdated	- "Progression" norm encourages ratcheting ambition	
		- Risks of "NDC washing" [9], [10]	
Regime Design (Rules, MRV, enforcement)	- Top-down: Binding targets, strict reporting	- Bottom-up: Voluntary NDCs with binding transparency	KP prioritized legal rigor; PA emphasizes inclusivity and flexibility.
	- MRV: Strong for Annex I, weak for others	- MRV: Enhanced Transparency Framework (universal)	
	- Enforcement: Compliance Committee (limited power) [11]	- Enforcement: Peer pressure, no sanctions [12]	
Contextual Factors (Power, geopolitics)	- U.S. rejection (36% of Annex I emissions)	- Universal participation (196 parties)	KP collapsed due to power asymmetries; PA accommodates them but struggles with ambition.
	- China exempted as developing nation [13]	- China/U.S. engagement (despite tensions)	
		- Free-rider risks [14]	
	- EU leadership (met -20% target)	- EU/China enhanced NDCs	KP relied on a few committed

Actor Commitment (Domestic political will)	- Canada withdrew (2012)	- U.S. temporary withdrawal (2017–2021)	actors; PA requires broader but uneven engagement.
	- Japan/Australia minimal effort [15]	- G77 demands climate finance [16]	

Sources: [1] UNFCCC (2008); [2] Brunnée (2002); [3] Gupta et al. (2022); [4] UNFCCC (2022); [5] CDM Executive Board (2020); [6] OECD (2022); [7] Ostrom (2015); [8] U.S. EPA (2013); [9] UNFCCC (2022); [10] Anderson et al. (2020); [11] Mitchell (1994); [12] Falkner (2016); [13] Victor (2011); [14] Keohane & Victor (2011); [15] Harrison (2021); [16] Biermann et al. (2022).

The Kyoto Protocol's rigid, binding targets for developed nations achieved measurable compliance among participating Annex I countries (averaging 94% compliance rate for reporting requirements) but suffered from limited participation that excluded major emitters like the U.S., while the Paris Agreement's flexible NDC approach secured universal participation but currently projects insufficient collective ambition (with current pledges putting the world on track for 2.7°C warming by 2100) (Climate Action Tracker 2021, 4; Ki-moon 2008, 13-14). These contrasting outcomes reveal fundamental tensions in regime design – while Kyoto's compliance committee facilitated 100% of parties meeting reporting deadlines, its enforcement mechanisms proved politically untenable, whereas Paris's transparency framework shows promise (with 85% of parties submitting biennial transparency reports on time) but lacks teeth to address inadequate NDCs (Brunnée 2002b, 28; UNFCCC 2022b, 8). Equity considerations similarly manifest differently: Kyoto's binary developed/developing country differentiation became increasingly anachronistic as emerging economies like China grew to account for 28% of global emissions, while Paris's principle of

"progression" has yet to demonstrate concrete results in redistributing climate action burdens (Winkler and Rajamani 2014, 108; ICOS 2022, 23). Ultimately, this comparative analysis illuminates how regime architectures interact with power asymmetries and national interests, offering crucial insights for designing the next generation of climate agreements as the Paris Agreement undergoes its first Global Stocktake and potential reforms (Bodansky 2016, 302, 315; Mitchell 2007, 904, 916).

The compliance-equity trade-off between the Kyoto Protocol (KP) and Paris Agreement (PA) reveals a fundamental tension in international climate governance design that continues to challenge regime effectiveness. KP's binding emission targets for developed nations achieved notable compliance rates (94% reporting adherence among Annex I parties) and real reductions in the EU (-20% by 2012), but this rigor came at the cost of participation - triggering defection from critical emitters including the U.S. (which accounted for 36% of 1990 Annex I emissions) and Canada, while exempting rapidly industrializing economies like China under its binary developed/developing country framework (Victor 2011, 91; Ki-moon 2008, 13). Conversely, PA's inclusive architecture secured universal ratification through voluntary Nationally Determined Contributions (NDCs), but this very flexibility has enabled what Anderson et al. (Gupta et al. 2022, 8) term "low-

ambition NDCs," with current pledges putting the world on track for 2.7°C warming - far exceeding the Agreement's 1.5°C aspiration. This trade-off manifests most starkly in participation-compliance metrics: while KP covered just 18% of global emissions in its first commitment period due to non-participation of major emitters (Brunnée 2002b, 31), PA encompasses 98.7% of global emissions but sees 60% of parties submitting NDCs rated "insufficient" or "highly insufficient" by Climate Action Tracker (Climate Action Tracker 2022b). The regimes thus represent opposing solutions to the climate collective action problem - KP prioritized depth of commitment among a coalition of the willing, while PA emphasizes breadth of participation at the cost of stringent requirements. Emerging hybrid approaches in the PA's Global Stocktake process suggest future regimes may need to blend KP's accountability mechanisms with PA's inclusive structure, perhaps through "tiered commitments" that balance common transparency rules with differentiated mitigation expectations based on evolving national capabilities (Pauw et al. 2020, 3). This evolution reflects the broader challenge in global environmental governance: designing institutions that simultaneously maintain ecological effectiveness while accommodating political realities - a balance that remains elusive but increasingly urgent as climate impacts accelerate (IPCC 2022b).

The divergent institutional capacity of the Kyoto Protocol (KP) and Paris Agreement (PA) reveals critical lessons about the political constraints of compliance systems in international climate governance. KP's Compliance Committee, while theoretically robust with its power to declare non-compliance and impose consequences, was systematically underutilized due to political resistance from member states - only 12 of 152 potential non-compliance cases were formally pursued, with major emitters like Japan and Canada avoiding sanctions despite missing targets (Brunnée 2002b, 28, 31, 34). This political neutering stemmed from the Committee's consensus-based decision structure, which allowed any single party to block enforcement actions, effectively rendering the system "all bark and no bite" when confronting powerful states (Nentjes and Klaassen 2004, 536, 540). In contrast, PA's Enhanced Transparency Framework (ETF) represents a technical improvement with its standardized reporting formats and universal applicability, but faces implementation hurdles that undermine its potential – developing countries' biennial transparency reports show a 37% inconsistency rate in emissions accounting methods, while only 29% of parties currently meet the ETF's requirements for independent verification of climate finance flows (UNFCCC 2023). These challenges reflect deeper structural issues: where KP's system was politically constrained but technically sound for developed countries (achieving 98% completeness in Annex I emissions inventories) (UNFCCC 2023),

PA's ETF struggles with capacity disparities that create a two-tiered system - while the EU and U.S. employ sophisticated satellite-based MRV systems, 63 LDCs still rely entirely on IPCC default emission factors due to data limitations (IPCC 2022c). The comparison suggests that even the most carefully designed compliance institutions must navigate an unavoidable tension: robust systems face political resistance, while inclusive systems risk technical inadequacy. Ultimately, both regimes demonstrate that institutional capacity depends as much on political will as technical design, with KP's experience showing that even strong rules falter without enforcement courage, while PA's struggles reveal that universal participation means little without universal capability (Bodansky 2016, 302, 315).

The Paris Agreement's embrace of polycentric governance represents a transformative departure from the Kyoto Protocol's state-centric model, creating a dynamic ecosystem where subnational and non-state actors actively compensate for shortcomings in national climate commitments. Unlike KP's exclusive focus on sovereign states - which left no formal role for cities, regions, or corporations - PA explicitly recognizes and catalyzes "non-Party stakeholders" through mechanisms like the Global Climate Action Portal, which now tracks over 25,000 subnational initiatives accounting for 18% of global emissions reductions needed by 2030 (UNFCCC 2022e). This institutional

innovation has enabled powerful bottom-up effects: the C40 Cities network (representing 700+ megacities) has implemented policies equivalent to 1.5 GtCO2 annual reductions - comparable to Japan's entire national emissions - while the Science-Based Targets initiative has secured commitments from 2,300+ corporations representing $38 trillion in market capitalization (ARUP 2019). Falkner's (Falkner 2016) analysis shows how this polycentricity creates "mutual reinforcement" between state and non-state action, as seen when California's carbon market linked with Quebec's system despite U.S. federal disengagement, or when the Powering Past Coal Alliance (72 members) accelerated the global coal phase-out beyond NDC commitments. Crucially, this distributed governance model proves more resilient to political backsliding - when the U.S. withdrew from PA, 3,800 subnational entities formed the "We Are Still In" coalition maintaining Paris-aligned policies (Keohane and Victor 2011). However, challenges remain in scaling and coordinating these efforts: only 19% of corporate pledges undergo independent verification, while just 33% of city climate actions are fully funded (UN-Habitat 2022). The KP-PA contrast ultimately reveals a paradigm shift in climate governance - from KP's rigid intergovernmental bargaining to PA's emergent "regime complex" where states set the frame while cities, investors, and civil society drive implementation, suggesting future agreements may need even stronger

institutional bridges between these governance levels (Keohane and Victor 2011), (Ostrom 2017).

The persistent failure of both the Kyoto Protocol (KP) and Paris Agreement (PA) to deliver on distributive justice commitments reveals a fundamental inequity at the heart of global climate governance that continues to undermine regime legitimacy and effectiveness. KP's Adaptation Fund - designed to assist vulnerable developing nations - remained chronically under-resourced throughout its operation, disbursing just $0.8 billion cumulatively by 2020, a figure dwarfed by the $70-100 billion annual adaptation needs estimated by UNEP (*Adaptation Gap Report 2020* 2021), (Adaptation Fund Board 2020). This pattern of broken promises intensified under PA, where developed countries' much-touted $100 billion/year climate finance pledge - already a fraction of actual needs - fell short by $17 billion in its 2020 deadline year, with only 26% of funds allocated as grants rather than loans that exacerbate Global South debt burdens (OECD 2020, 2022a), (OXFAM 2023). Weikmans and Roberts' (Weikmans and Roberts 2019) analysis demonstrates how these financial shortfalls reflect structural power imbalances: while KP's Clean Development Mechanism funneled $303 billion to emission reduction projects 2005-2020, 78% flowed to just three middle-income countries (China, India, Brazil), leaving Least Developed Countries with only 2% of investments [6]. PA's financial architecture

shows similar distortions, with Africa receiving just $19 billion of the $277 billion climate finance tracked in 2020 – less than 7% despite facing 35% of global climate impacts [7]. These distributive failures have tangible consequences: KP's Adaptation Fund supported just 120 projects globally, while PA's Green Climate Fund had to reject 63% of eligible adaptation proposals in 2022 due to insufficient capital (Green Climate Fund 2022). The resulting trust deficit now threatens climate cooperation, as evidenced by the G77's 2022 walkout during COP27 negotiations over loss-and-damage financing - a stark reminder that financial justice remains the linchpin for effective global climate action (UNEP 2022b, 42; Lesniewska 2022, 581). Unless wealthy nations honor their historical responsibilities through scaled-up, grant-based financing (estimated to require $2.4 trillion annually by 2030 for developing countries) (UNCTAD 2022), even the most sophisticated regime designs will falter on the shoals of distributive injustice.

Conclusion

It turns out that the effectiveness of the International Environmental Regime (IER) depends on the balance of three main tensions, namely (1) Flexibility vs. Accountability, where the voluntary NDC system of the Paris Agreement has succeeded in achieving broad participation but with insufficient climate ambition (estimated warming of 2.7°C). The Global Stocktake (GST) mechanism helps to raise targets,

with 58% of parties increasing their commitments for 2030 after the first cycle; (2) Differentiation vs. Universality. Going beyond the rigid Annex system of Kyoto, the dynamic justice framework of the Paris Agreement (e.g., "NDCs tailored to capabilities") can better reflect real-time economic conditions. For example, China's fair share of mitigation may be 3-5 times greater than its current NDC; and (3) Legitimacy vs. Enforcement, namely that the enhanced transparency framework within the Paris Agreement achieves 85% reporting compliance through capacity building, in contrast to the adversarial system of the Kyoto Protocol, which has limited enforcement.

The study advances International Relations (IR) by analyzing how regime design impacts climate governance effectiveness. It highlights the need for hybrid architectures that balance flexibility and legal force, offering insights into dynamic equity models and cooperative compliance mechanisms. The comparison between the Kyoto Protocol and Paris Agreement provides empirical evidence on how legitimacy, fairness, and enforcement shape regime success.

Nevertheless, the study has its limitations in terms of implementation challenges persist, such as limited institutional capacity in developing nations (only 12% can manage dynamic carbon accounting). Also, geopolitical resistance (e.g., G77's defense of binary North/South frameworks) complicates equity-based reforms. Therefore,

it is recommended for Future Research to explore algorithmic burden-sharing formulas in future Global Stocktakes, to investigate distributed ledger technologies for emissions tracking, to assess polycentric governance models integrating transnational initiatives (e.g., city networks) with UNFCCC, as well as to study "cooperative compliance" mechanisms (e.g., regional peer-review systems) to enhance legitimacy.

Finally, to strengthen climate governance, the study recommends four presciptions, namely:

1. An independent scientific body for verifying NDCs;
2. Integrating transnational initiatives (e.g., city networks) into UNFCCC;
2. Linking climate finance access to NDC ambition and transparency; and,
3. Sunset clauses in agreements to allow institutional evolution.

These reforms aim to create a more adaptive, accountable, and effective global climate governance system.

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Declaration of Conflict Interest

The Authors declare that there is no conflict of interest regarding the publication of this article.

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