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*Review*

# Stalemate in the Anthropocene: Ineffective Treaties and the Struggle for Planetary Governance

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**Abstract**

This paper traces the evolution of global environmental agreements from 1971 to 2025 and explains why a dense treaty architecture has not delivered commensurate improvements in planetary conditions. Using qualitative comparative document analysis of major multilateral environmental agreements across climate, biodiversity, and pollution, the paper codes objectives, institutional designs, and observed performance. It integrates regime complex theory, planetary boundaries, and environmental justice to interpret recurrent weaknesses in this regime complex. The analysis identifies three consistent empirical patterns. First, implementation and enforcement gaps persist across issue areas, as global indicators for biodiversity, greenhouse gas emissions, and pollution-related mortality continue to diverge from agreed goals and targets. Second, states respond to the triple planetary crisis through a fragmented institutional landscape that multiplies mandates and reporting obligations while achieving limited coordination or policy integration. Third, distributive and procedural injustices endure because populations that contribute least to environmental degradation bear disproportionate harm and confront chronic shortfalls in finance, technology transfer, and voice in decision-making. These three patterns reinforce one another and create a structurally underpowered regime complex when evaluated against planetary boundaries and justice claims. The paper argues that incremental treaty proliferation cannot close these gaps. Instead, global environmental governance must shift toward implementation-centered Conferences of the Parties, stronger but fair compliance mechanisms, deliberate inter-regime coordination, and justice-oriented reforms in finance and rights. This diagnosis provides a foundation for future empirical evaluations of treaty impact and for normative debates on how to realize a safe and just operating space for humanity.

**Keywords:** multilateral environmental agreements; regime complex; implementation gaps; fragmentation; environmental justice; planetary boundaries; compliance

## 1. Introduction

The modern era of global environmental law began with a handful of conservation treaties that states negotiated in the early 1970s in the wake of the 1972 Stockholm Conference. Governments adopted the Convention on Wetlands of International Importance (Ramsar) in 1971, the World Heritage Convention in 1972, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973. These agreements focused on specific ecosystems and species and reflected mounting concern that national action alone could not protect shared natural heritage.

Over subsequent decades, the scope of multilateral environmental agreements (MEAs) broadened. States launched the United Nations Environment Program (UNEP) Regional Seas Program in 1974 to tackle marine pollution, adopted the Convention on Migratory Species (CMS) in

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1979, and negotiated the Basel Convention on hazardous waste in 1989. The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer became a landmark in preventive global regulation, while the 1992 Rio Earth Summit produced framework conventions on climate change and biodiversity that continue to structure global negotiations today.

By the 2010s and 2020s, governments explicitly framed this trajectory around a triple planetary crisis of climate change, biodiversity loss, and pollution [42]. They adopted the Paris Agreement in 2015, the Kunming-Montreal Global Biodiversity Framework (GBF) in 2022, the High Seas Treaty in 2023, and, in 2025, agreed to establish an Intergovernmental Science-Policy Panel on Chemicals, Waste and Pollution to complement the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [6,44,50,52].

Despite this dense architecture, many global environmental indicators remain deeply troubling. The planetary boundaries framework suggests that humanity already transgresses or approaches critical thresholds in several Earth-system processes, including climate change, biosphere integrity, and the emergence of novel entities such as chemical pollution [29,33,35]. Global assessments of biodiversity targets report only partial progress toward agreed goals, and updated estimates indicate that pollution continues to cause roughly nine million premature deaths annually, with limited evidence of a declining trend [17,19,24,37].

This tension raises a central question: How and why have five decades of multilateral environmental treaty-making produced a sophisticated legal architecture without commensurate improvement in planetary-scale environmental outcomes? This article is therefore best read as a theory-informed comparative review of institutional design across regimes, rather than as an attempt to estimate the causal effect of any single agreement.

To engage this question, this paper pursues three objectives: (a) to reconstruct the evolution of major global environmental agreements between 1971 and 2025, using milestone instruments highlighted in UNEP timelines and the wider literature as a backbone; (b) to identify and analyze recurrent weaknesses in this regime complex, focusing on implementation and enforcement, institutional fragmentation and distributive justice; and (c) to situate these patterns within a theoretical framework that integrates regime complex analysis, planetary boundaries and environmental justice, and to articulate the implications for future research and policy design.

The argument proceeds in an analytic narrative mode, drawing on documentary evidence and scholarly work rather than original quantitative modelling. The aim is not to provide an exhaustive history of every environmental treaty but to trace representative dynamics that structure contemporary planetary governance and to offer a theoretically grounded explanation for persistent performance gaps.

Environmental Development emphasizes locally and regionally grounded work with global relevance. Although this review analyzes global treaty architecture, its focus is explicitly on how institutional design choices shape the finance, capacity, accountability, and distributional conditions that determine implementation in practice. In that sense, the paper treats the performance of multilateral agreements as an upstream determinant of environmental development outcomes, including progress toward the Sustainable Development Goals through national and subnational policy translation.

## 2. Theoretical and Methodological Approach

### *2.1. Regime Complexes and Fragmentation*

A regime complex is a loosely coupled set of institutions that address a common issue area without forming a single, integrated regime [23]. Climate governance, for instance, comprises the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement, the Montreal Protocol, the International Civil Aviation Organization's offsetting scheme, and numerous transnational initiatives.

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Fragmentation arises when multiple institutions with overlapping mandates, divergent norms, and separate decision-making centers operate in parallel [3]. Fragmentation can generate useful experimentation and flexibility, but it can also create inconsistency, duplication, and gaps. This paper treats the ensemble of global environmental agreements as a regime complex and uses fragmentation theory to analyze how treaty proliferation shapes coherence, coordination, and effectiveness.

### *2.2. Planetary Boundaries*

The planetary boundaries framework proposes quantitative limits for key Earth-system processes that together define a safe operating space for humanity [33,35]. The framework initially identified nine boundaries, including climate change, biosphere integrity (originally biodiversity loss), biogeochemical flows, and chemical pollution [33]. Subsequent refinements updated the control variables and emphasized climate change and biosphere integrity as core boundaries that strongly influence the overall state of the Earth system [35].

While planetary boundaries research does not prescribe specific institutional designs, it offers powerful benchmarks for evaluating whether the environmental regime complex, in aggregate, aligns human activity with biophysical limits. This paper uses planetary boundaries as a reference frame to assess whether 50 years of treaty-making match the scale and speed of the required transformations.

### *2.3. Environmental Justice*

Environmental justice research examines how environmental burdens and benefits distribute across social groups and countries, how different cultures and knowledges gain recognition, and how decision-making processes enable or deny meaningful participation. In the climate and biodiversity regimes, principles such as common but differentiated responsibilities, respective capabilities, and fair and equitable benefit-sharing embed justice considerations in legal texts [27,28]. Yet debates over finance, technology transfer, and loss and damage show that practice often diverges from these norms.

By foregrounding justice, this paper treats questions of responsibility, vulnerability, and voice as central to regime effectiveness. It argues that perceptions of fairness shape states' willingness to accept stronger obligations and to support more robust compliance and enforcement mechanisms.

### *2.4. Methodology*

This paper uses qualitative comparative document analysis to compare how major multilateral environmental agreements (MEAs) are designed, coordinated, and implemented, and how they perform against widely used system-level outcome indicators. The unit of analysis is the regime instrument (treaty, protocol, or COP-adopted framework), interpreted together with its core implementing rules and procedures.

Case selection. The sample is limited to global MEAs that anchor the three pillars of the triple planetary crisis (climate, biodiversity, and pollution or chemicals) and that have established institutional machinery (a COP or equivalent) plus a reporting process. The core set includes Ramsar (1971), World Heritage (1972), CITES (1973), MARPOL (1973/78), CMS (1979), the Vienna Convention and Montreal Protocol (1985/1987), the UNFCCC and related instruments (Kyoto and Paris), the CBD and related instruments (Cartagena Protocol and Nagoya Protocol) and the Kunming-Montreal Global Biodiversity Framework, the UNCCD, and the Rotterdam, Stockholm, and Minamata Conventions, plus the 2025 UNEA decision establishing the intergovernmental science policy panel on chemicals, waste and pollution.

Document corpus. For each instrument, the analysis reviews (a) treaty text and amendments, (b) compliance and implementation procedures where applicable, (c) selected COP decisions that establish reporting, finance, transparency, or compliance arrangements, and (d) authoritative

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synthesis assessments (for example UNEP, IPCC, IPBES, the Lancet Commission, and peer-reviewed reviews). Full citations appear in the References.

For transparency, COP decisions were selected when they created, revised, or operationalized reporting, compliance, finance, transparency, or coordination procedures that materially shaped implementation across parties. Routine administrative decisions and highly technical updates were not coded unless they altered those institutional functions.

Coding. Each instrument is coded on three dimensions aligned with the theoretical framework: (1) implementation and enforcement, (2) fragmentation and coordination, and (3) justice and distribution. Coding follows a structured codebook with defined categories and decision rules (Appendix A). The codebook captures obligation form, targets and timelines, reporting and transparency requirements, compliance architecture, finance and technology support, coordination mechanisms, and explicit justice provisions. Coding was applied consistently across agreements, with a verification pass to resolve ambiguities and ensure comparability across issue areas.

Coding proceeded through a structured comparative reading of each instrument and its core implementing rules. For each case, the analysis recorded obligation form, target structure, reporting architecture, finance and technology provisions, coordination clauses, and justice-relevant language, and then compared those features across issue areas to identify recurring institutional patterns. Appendix A reports the coding variables and decision rules used to maintain comparability across cases.

Performance indicators. To connect institutional design to real-world conditions without implying causal attribution, the paper uses a small set of widely cited global indicators (Table 2) that reflect the state of climate, biodiversity, and pollution. These indicators are treated as contextual benchmarks, not as measures of the impact of any single treaty.

Triangulation and analysis. Coding results are compared across issue areas to identify recurring patterns and then interpreted using regime complex theory, planetary boundaries, and environmental justice scholarship. Where treaty performance is discussed, claims are anchored in synthesis assessments rather than isolated cases.

The study is interpretive rather than causal. Its purpose is to diagnose recurrent design features across regimes and relate those features to authoritative system-level indicators and synthesis assessments, not to isolate the independent effect of any single treaty.

Limitations. The analysis relies primarily on existing assessments and on documents that vary in depth and availability across regimes. It cannot attribute observed indicator trends to any single MEA. Its contribution is a transparent cross-regime diagnosis of institutional design features that recur across agreements and that plausibly contribute to persistent governance gaps.

## 3. From Conservation Islands to a Global Regime Complex (1971-2025)

Over the past five decades, global environmental governance has shifted from a handful of isolated conservation initiatives to an increasingly dense and interconnected architecture of treaties and institutions. This transformation from scattered “conservation islands” to a global regime complex is summarized in Figure 1, From Conservation Islands to a Global Regime Complex (1971-2025), which maps the emergence and layering of key multilateral environmental agreements over time.

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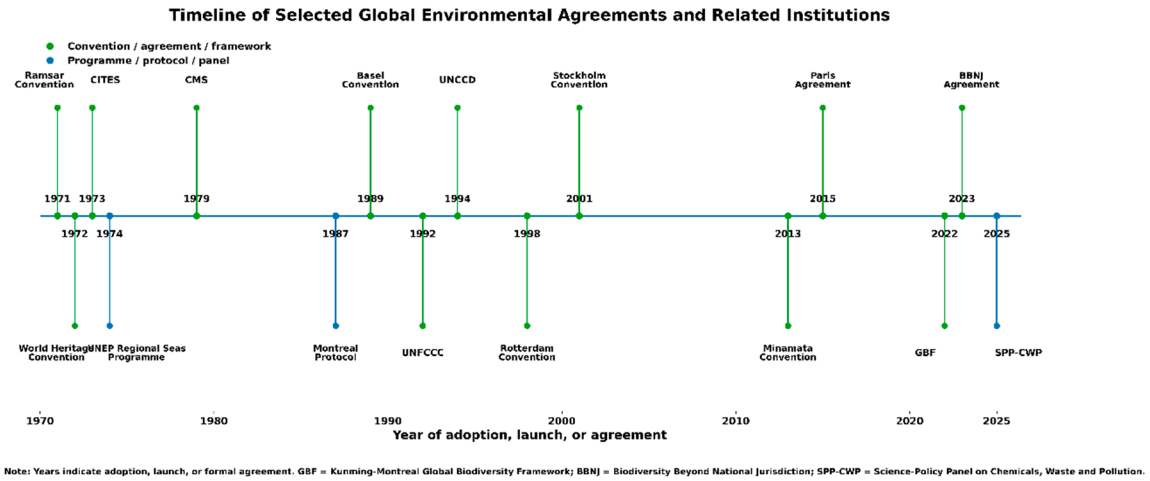


**Figure 1.** Timeline of key global environmental agreements from 1971 to 2025. Note. The timeline is synthesized from treaty adoption dates reported in the United Nations Treaty Collection and related convention secretariats; the visualization is an original figure created by the authors.

Figure 1, highlighting major multilateral treaties on wetlands, hazardous waste, biodiversity, climate change, chemicals, and high seas governance. The selection of major global environmental agreements is not a comprehensive list of all international, regional, or sector-specific treaties. The years shown indicate the adoption dates of the agreements and may differ from the dates when they entered into force or were ratified by individual countries. For detailed and up-to-date information on specific treaties, readers should consult official United Nations treaty databases and primary legal sources.

Table 1 summarizes the core set of multilateral environmental agreements and frameworks used in this analysis and highlights design features that matter for effectiveness.

**Table 1.** Core multilateral environmental agreements and salient design features (1971-2025).

| Instrument | Year adopted | Primary issue area | Design feature relevant to performance |
|---|---|---|---|
| Ramsar Convention | 1971 | Wetlands | Designation of sites; 'wise use' approach; limited compliance machinery |
| World Heritage Convention | 1972 | Natural and cultural heritage | Listing and funding; reliance on national protection measures |
| CITES | 1973 | Wildlife trade | Trade permit system; enforcement mainly via domestic customs controls |
| UNEP Regional Seas Program | 1974 | Marine pollution (regional) | Nested regional action plans; variable binding force across regions |
| Convention on Migratory Species (CMS) | 1979 | Migratory species | Cooperation on species conservation; limited leverage on drivers |

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|---|---|---|---|
| Montreal Protocol | 1987 | Ozone-depleting substances | Binding phase-out schedules; Multilateral Fund for finance/technology |
| Basel Convention | 1989 | Hazardous waste | Prior informed consent for waste movements; heavy reliance on domestic enforcement |
| UNFCCC | 1992 | Climate change | Framework goals; substantive action via subsequent instruments and COP decisions |
| Convention on Biological Diversity (CBD) | 1992 | Biodiversity | Broad objectives; implementation via national plans and COP decisions |
| UNCCD | 1994 | Desertification/land degradation | National action programmes; chronic underfunding challenges |
| Rotterdam Convention | 1998 | Hazardous chemicals trade | Prior informed consent for listed chemicals; listing politics |
| Stockholm Convention | 2001 | Persistent organic pollutants | Elimination/restriction of listed POPs; incremental listing approach |
| Minamata Convention | 2013 | Mercury | Controls on supply, products, emissions; major source challenges (ASGM) |
| Paris Agreement | 2015 | Climate mitigation/adaptation | Nationally determined contributions; transparency and stocktake |
| Kunming-Montreal GBF | 2022 | Biodiversity targets to 2030 | 23 targets incl. 30x30; depends on updated NBSAPs and finance |
| BBNJ Agreement (High Seas Treaty) | 2023 | Biodiversity beyond national jurisdiction | High seas MPAs and EIAs; interacts with regional/sectoral bodies |
| SPP-CWP (science-policy panel) | 2025 | Chemicals, waste, pollution science-policy interface | Assessment function to complement IPCC/IPBES; coordination opportunity |

*Note*. Years refer to adoption dates; entry into force and country ratification timelines vary by instrument.

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Taken together, these milestones provide a foundation for understanding how international environmental governance has evolved. Building on this timeline, the following discussion examines each agreement in greater detail, focusing on its objectives, key provisions, and implications for global environmental protection.

### *3.1. Conservation and Heritage in the 1970s*

The Ramsar Convention on Wetlands of International Importance (1971) commits parties to designate wetlands for inclusion on an international list and to promote their wise use [30]. Its institutional design emphasizes national sovereignty and cooperation and provides only minimal compliance machinery.

In 1972, the World Heritage Convention linked cultural and natural heritage in a single legal instrument, establishing a World Heritage List and a fund to support conservation of sites with outstanding universal value [39]. Its twin focus on culture and nature anticipates later calls for integrated socio-ecological governance.

The 1973 adoption of CITES and the 1979 Convention on Migratory Species extend multilateral regulation to wildlife trade and transboundary animal populations [8,10]. These treaties primarily coordinate national controls on harvest and trade rather than tackle underlying drivers such as habitat conversion, agricultural expansion, and infrastructure development.

UNEP's Regional Seas Program, launched in 1974, introduces a different model: regional cooperative frameworks and action plans for shared marine ecosystems, many of which are supported by binding conventions and protocols [40,41]. This early move toward nested governance foreshadows later debates about scale, subsidiarity, and the division of labor between global and regional institutions.

### *3.2. Pollution Control and the Montreal Success in the 1980s*

During the 1980s, scientific evidence of stratospheric ozone depletion and growing concern over hazardous-waste exports spurred the development of more ambitious agreements. The Basel Convention (1989) regulates transboundary movements of hazardous waste through a system of prior informed consent and obligations for environmentally sound management [2]. Enforcement depends heavily on domestic customs and port authorities, and illegal shipments continue to surface, especially in the context of electronic waste and ship-breaking [9].

The Montreal Protocol (1987), adopted under the 1985 Vienna Convention, represents one of the clearest success stories. Parties agree to time-bound phase-out schedules for chlorofluorocarbons and other ozone-depleting substances, supported by a Multilateral Fund that finances technology transfer in developing countries. Scientific assessments indicate that atmospheric concentrations of many regulated substances have declined, and that the ozone layer is on a path to recovery, assuming continued compliance [55]. Montreal demonstrates that, when credible finance and feasible substitutes exist, states can accept stringent, enforceable obligations.

### *3.3. The Rio Conventions and Sustainable Development in the 1990s*

The 1992 United Nations Conference on Environment and Development produced the UNFCCC and the CBD, while the 1994 United Nations Convention to Combat Desertification (UNCCD) addresses land degradation in arid and semi-arid regions [5,38,49].

The UNFCCC sets the objective of stabilizing greenhouse gas concentrations at levels that would prevent dangerous anthropogenic interference with the climate system, but does not specify quantified emission limits. The 1997 Kyoto Protocol set binding targets for a subset of industrialized countries; however, several major emitters did not participate or later withdrew, limiting its coverage and political traction [16].

The CBD articulates three objectives: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from genetic resources.

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Subsequent protocols and decisions elaborate on access and benefit-sharing and biosafety rules. Yet assessments of progress toward the CBD's 2011-2020 Aichi Targets show that, although policy responses increased, most state-of-biodiversity indicators did not improve globally [17,37].

The UNCCD, motivated by concern over desertification and drought in Africa and beyond, adopts a bottom-up approach centered on national action programs and local participation. Chronic underfunding and weak integration with climate and biodiversity agendas undermine its influence [7].

Taken together, the Rio conventions shift global environmental law from narrow conservation toward the broader language of sustainable development but rely primarily on framework architectures, deferring many substantive decisions to later Conferences of the Parties and domestic implementation.

### *3.4. Expanding Chemicals and Waste Governance, 1998-2013*

In the late 1990s and early 2000s, governments negotiated the Rotterdam Convention on Prior Informed Consent for Certain Hazardous Chemicals and Pesticides in International Trade (1998) and the Stockholm Convention on Persistent Organic Pollutants (2001) [34,36]. These agreements establish procedures for listing new substances and introduce obligations to control or eliminate those designated as particularly hazardous.

The Minamata Convention on Mercury (2013) adds a third pillar to global chemicals governance, targeting mercury emissions from industrial processes, artisanal and small-scale gold mining, and other sources [25].

Despite these advances, global assessments show that chemical pollution remains a major threat to human health and ecosystems. The Lancet Commission on Pollution and Health estimates that pollution caused approximately nine million premature deaths in 2015, with updated analysis suggesting similar figures in 2019 [11,19,24]. This persistent burden highlights a structural gap between controls on specific substances and the proliferation of thousands of unregulated or poorly studied chemicals and waste streams [29].

### *3.5. Iterative Ambition in the Climate Regime: The Paris Agreement*

The 2015 Paris Agreement, adopted as decision 1/CP.21 under the UNFCCC, introduces a hybrid model. Parties collectively agree to limit global temperature rise to well below 2 °C and to pursue efforts to stay below 1.5 °C, while each party submits nationally determined contributions (NDCs) that it updates every five years in light of a global stocktake [50].

The Agreement relies on a predominantly procedural enforcement system that centers on transparency, review, and peer pressure rather than top-down sanctions [4]. This design recognizes political constraints and concerns about sovereignty, but it also means that shifts in domestic politics can stall or reverse NDC ambition. UNEP's Emissions Gap Reports show that the aggregate effect of current NDCs remains insufficient to place the world on a likely pathway to 1.5 °C, although implemented policies moderate worst-case warming scenarios compared with a no-policy baseline [43].

A concrete example illustrates this enforcement gap. Several parties pledge to phase out unabated coal power, yet new coal-fired plants continue to appear in planning or construction pipelines, sometimes with foreign public or private finance [22]. The legal architecture does not prohibit such investment; it only requires that parties reflect their actions in NDCs and long-term strategies.

### *3.6. Integrating Biodiversity and the Oceans in the 2020s*

Recognizing limited progress under the Aichi Targets, CBD COP15 adopted the Kunming-Montreal Global Biodiversity Framework in 2022. The GBF sets 23 targets for 2030, including conserving at least 30% of land, inland water, and marine areas; reducing harmful subsidies; restoring

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degraded ecosystems; and ensuring gender-responsive, participatory governance [6,26]. Parties now face the task of translating this framework into updated national biodiversity strategies and action plans.

In 2023, states concluded the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction, commonly known as the High Seas Treaty, under the United Nations Convention on the Law of the Sea [52]. The treaty enables parties to designate marine protected areas in the high seas, sets rules for environmental impact assessment, and establishes principles for sharing benefits from marine genetic resources. By September 2025, at least 60 ratifications had been deposited, triggering the treaty's entry into force in early 2026 [20].

These instruments attempt to address recognized gaps: limited protection of biodiversity in areas beyond national jurisdiction and the failure to meet earlier biodiversity goals. Their success will depend on the ambition of domestic implementation and on the degree of coordination with existing fisheries organizations, regional seas conventions, and sectoral bodies.

### *3.7. The 2025 Chemicals, Waste, and Pollution Panel*

In June 2025, following negotiations mandated by the United Nations Environment Assembly resolution 5/8, governments agreed to establish an Intergovernmental Science-Policy Panel on Chemicals, Waste, and Pollution [44,45]. The panel aims to provide authoritative assessments analogous to those of the IPCC and IPBES and to work with existing MEAs and the new Global Framework on Chemicals.

The panel directly addresses concerns that knowledge of chemical and waste impacts remains fragmented and that policy responses lag. Its creation further densifies the regime complex while offering an opportunity to integrate scientific advice more effectively across the pollution pillar of the triple planetary crisis.

## 4. Cross-Cutting Weaknesses in the Global Environmental Regime

### *4.1. The Implementation and Enforcement Gap*

Across issue areas, a recurrent pattern appears: negotiated commitments outpace implementation. This emerges most clearly when treaty ambitions are compared with empirical trends.

Biodiversity assessments indicate that, despite increased policy responses, global indicators such as species extinction risk and habitat loss have shown little or no improvement [17,37]. Planetary boundaries analyses similarly conclude that climate change, biosphere integrity, and several other processes already lie in or near zones of elevated risk [33,35]. Regarding pollution, the Lancet Commission finds that the disease burden attributable to pollution remained roughly 9 million deaths annually between 2015 and 2019, with no clear indication of a downward global trend [19,24]. Collectively, these findings suggest that existing instruments such as Basel, Rotterdam, Stockholm, and Minamata have not yet driven a decisive shift away from hazardous production and disposal practices, particularly in low- and middle-income countries.

Table 2 provides a compact empirical snapshot that illustrates the mismatch between treaty ambitions and observed system-level indicators across the pillars of the triple planetary crisis.

**Table 2.** Selected global indicators illustrating implementation gaps across climate, biodiversity, and pollution.

| Indicator | Latest estimate | Relevance to regime performance | Source (see References) |
|---|---|---|---|
| Global greenhouse gas emissions | 57.1 GtCO2e (2023) | System-level benchmark for whether the climate regime complex is bending the global emissions curve; useful for | UNEP Emissions Gap Report 2024 |

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| | | | |
|---|---|---|---|
| | | comparing trajectory against 1.5°C and 2°C pathways. | |
| Pollution-attributable premature deaths | Approximately 9 million deaths (latest consolidated estimate) | Captures persistence of major health harms despite decades of pollution governance (for example Stockholm, Minamata, chemicals frameworks), and links environmental performance to human wellbeing. | Fuller et al. (2022) |
| Planetary boundaries status | 6 of 9 boundaries transgressed (latest synthesis) | High-level adequacy check across regimes: indicates whether aggregate governance is consistent with a safe operating space for humanity. | Richardson et al. (2023) |
| Species threatened with extinction | Approximately 1 million species (IPBES estimate) | Outcome indicator for biodiversity governance that underscores the scale of ecological decline relative to treaty and framework ambitions. | IPBES Global Assessment (2019) |
| Aichi Targets (2011 to 2020) performance | No target fully achieved at the global level | Tracks the gap between agreed biodiversity targets and implementation outcomes, and provides baseline context for the Global Biodiversity Framework. | CBD COP15 decision and related assessments |

Note. Estimates are reported as in the cited sources and are included here to illustrate magnitude and direction rather than to adjudicate causal attribution to any single treaty.

Institutionally, many MEAs rely on facilitative compliance mechanisms that emphasize dialogue, capacity-building, and problem-solving rather than sanctions. This approach can reduce conflict and encourage participation, but it also weakens incentives for timely implementation. Non-compliance procedures under the Kyoto Protocol and the Montreal Protocol involve committees that can recommend remedies but impose few penalties beyond reputational costs and potential restrictions on eligibility for specific mechanisms [53].

A realistic scenario illustrates how this gap plays out. Consider a coastal country party to Ramsar, the CBD, the GBF, the Paris Agreement, and the BBNJ Treaty. The country submits national reports and attends Conferences of the Parties; however, its environmental agencies remain under-resourced, and land-use decisions prioritize short-term economic growth. Wetlands listed under Ramsar gradually give way to infrastructure, fisheries subsidies contribute to over-exploitation, and offshore oil exploration occurs near proposed high-seas protected areas. Under current MEA designs, these dynamics may generate criticism and technical missions but rarely trigger binding consequences.

### *4.2. Fragmentation Across Regimes and Scales*

A second cross-cutting weakness involves fragmentation. Different MEAs address interlinked issues with separate mandates, membership, funding arrangements, and reporting requirements. Fragmentation can be structural, when multiple institutions lack overarching coordination; cognitive, when institutions frame problems differently; and normative, when they embed inconsistent principles [3].

Climate and biodiversity regimes illustrate these dynamics. The Paris Agreement focuses on greenhouse gases, while the GBF targets habitat conservation, species status, and sustainable use. Yet mitigation options such as bioenergy with carbon capture and storage or large-scale afforestation

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directly affect biodiversity and land systems [18]. Without strong cross-regime coordination, policies that advance one set of objectives can undermine another.

Chemicals and pollution governance show similar patterns. Basel, Rotterdam, Stockholm, and Minamata emerge sequentially to address specific substances or flows, while broader frameworks such as the Strategic Approach to International Chemicals Management and the new global chemicals framework provide voluntary coordination [25,34,36]. The new science-policy panel could reduce informational fragmentation, but only if it forges robust links with these existing institutions and with health-focused bodies such as the World Health Organization [44,45,54].

At the regional level, the UNEP Regional Seas Program, regional fisheries management organizations, and other sectoral bodies overlay these global regimes [41]. Coordination among them remains uneven, despite some joint work programs. Fragmentation imposes tangible costs: officials in environmental ministries must prepare multiple national reports, sometimes with overlapping indicators but different timelines. Limited administrative capacity means that meeting reporting obligations can crowd out substantive policy-making. Fragmented funding streams may also support isolated projects rather than coherent national strategies.

The relationships among these agreements are easier to see than to describe. Figure 2 condenses the main interaction points across major regimes and illustrates where overlap and weak coordination most often create implementation frictions.

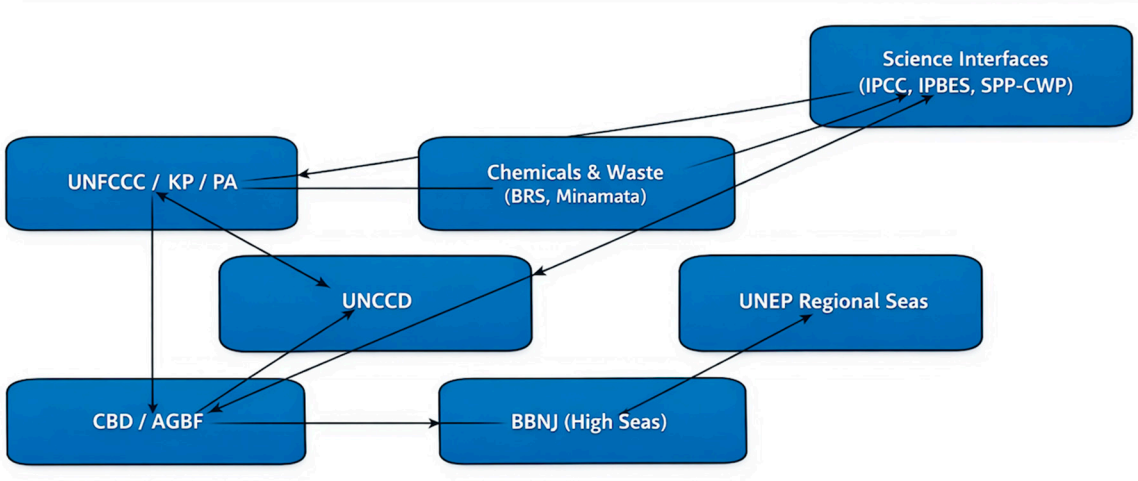


**Figure 2.** Simplified interaction map of major regimes within the environmental regime complex. Note. Conceptual map created by the authors to illustrate a subset of cross-regime interactions discussed in Section 4.2; it is not an exhaustive institutional inventory. UNFCCC = United Nations Framework Convention on Climate Change; CBD = Convention on Biological Diversity; UNCCD = United Nations Convention to Combat Desertification; BBNJ = Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction; BRS = Basel, Rotterdam and Stockholm Conventions; IPCC = Intergovernmental Panel on Climate Change; IPBES = Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services; SPP-CWP = Science Policy Panel on Chemicals, Waste and Pollution.

To translate the coordination problem shown in Figure 2 into concrete governance costs, Table 3 summarizes common manifestations of fragmentation and the practical burdens they create for implementation and reporting.

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**Table 3.** Illustrative manifestations of fragmentation and their governance costs.

| Fragmentation manifestation | Illustrative example | Governance consequence | Coordination response (illustrative) |
|---|---|---|---|
| Overlapping reporting requirements | Parallel national reports to UNFCCC, CBD/GBF, UNCCD, and chemicals conventions | Administrative load crowds out implementation capacity | Harmonize indicators and reporting calendars; shared data portals |
| Divergent sectoral mandates | Fisheries management, shipping, deep-sea mining, and biodiversity conservation operate under separate bodies | Gaps and conflicts in ocean governance, especially in areas beyond national jurisdiction | Joint work programmes and cross-referencing decisions across sectoral bodies |
| Sequential substance-by-substance regulation | Listing new POPs, pesticides, and mercury controls lag behind chemical innovation | Regulation trails production and trade; unassessed chemicals persist | Science-policy assessments (SPP-CWP) linked to faster listing and preventive approaches |
| Fragmented finance and projectization | Multiple small funding windows tied to separate treaties | Short-term projects rather than integrated national strategies | Pooled financing and programmatic funding aligned with national plans |

*Note.* Examples are illustrative and drawn from patterns discussed in Section 4.2 and related regime-complex scholarship.

These fragmentation costs are not evenly distributed; they often fall more heavily on capacity-constrained countries and communities, which makes equity and justice a central condition for whether coordination reforms can succeed.

### *4.3. Persistent Inequities and Limited Justice*

Justice concerns shape negotiations and implementation across MEAs. Developing countries emphasize historical responsibility for environmental degradation and the need for predictable financial and technological support; industrialized countries highlight the political and economic limits of open-ended commitments.

The climate regime institutionalizes these tensions through the principle of common but differentiated responsibilities and respective capabilities. Actual flows of climate finance, however, fall short of levels that many developing countries deem necessary for mitigation and adaptation, and protracted debates over the design of a loss-and-damage fund reveal deep mistrust [27,32].

In biodiversity governance, the GBF's Target 23 explicitly calls for gender-responsive, participatory approaches and recognizes the role of Indigenous peoples and local communities [6,26]. Realizing this target requires states to reshape domestic legal frameworks, property rights, and consultation mechanisms, which poses significant political and institutional challenges.

Environmental health studies demonstrate that pollution-related disease burdens fall disproportionately on low and middle-income countries, where regulation and enforcement capacities often remain weakest [11,19,24]. This distributional reality underscores that justice is not

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an abstract value but a practical determinant of regime effectiveness. Without credible pathways to fair burden-sharing, states have strong reasons to resist more stringent obligations and more intrusive compliance mechanisms.

Taken together, the preceding sections show how implementation gaps, fragmentation, and justice deficits can reinforce one another across the regime complex. Figure 3 synthesizes this argument by mapping the main feedback pathways that repeatedly appear across climate, biodiversity, and pollution governance. This synthesis clarifies why incremental institutional additions often struggle to shift system-level trajectories when coordination, compliance support, and distributional credibility remain weak.

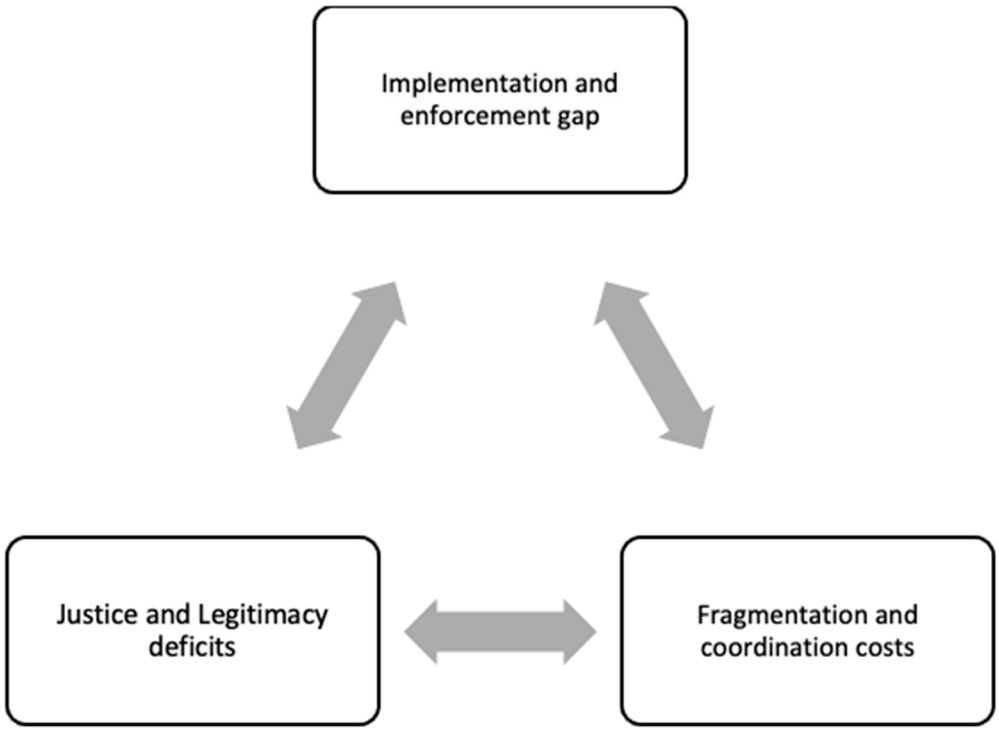


**Figure 3.** Reinforcing mechanisms linking implementation, fragmentation, and justice deficits. Note. Conceptual figure created by the authors to summarize the cross-cutting weaknesses identified in Sections 4.1-4.3.

To make the justice dimension more concrete across regimes, Table 4 provides a focused crosswalk of justice-relevant mechanisms and where they tend to appear in institutional design.

**Table 4.** Justice-relevant mechanisms across selected environmental regimes.

| Justice dimension | Where it appears | Intended function | Persistent gap highlighted in this paper |
|---|---|---|---|
| Common but differentiated responsibilities and respective capabilities (CBDR-RC) | UNFCCC and Paris Agreement | Allocates responsibilities considering historical emissions and capacity | Contestation over adequacy and predictability of climate finance; |

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| | | | |
|---|---|---|---|
| | | | uneven implementation |
| Technology transfer and capacity-building | Montreal Protocol Multilateral Fund | Enables feasible compliance through financing and technology access | Successful model not consistently replicated across other regimes |
| Fair and equitable benefit-sharing | CBD (and protocols) and GBF | Links conservation with benefits from genetic resources and related information | Ongoing disputes over benefit-sharing modalities and funding levels |
| Procedural rights and participation | GBF participation provisions for Indigenous peoples and local communities | Strengthens voice, recognition, and safeguards in implementation | Domestic legal and institutional changes often lag behind COP commitments |
| Exposure and vulnerability to pollution harms | Chemicals and waste conventions; public health guidelines | Aims to reduce hazardous exposures and protect health | Health burdens remain concentrated in low- and middle-income contexts with weaker enforcement capacity |

*Note*. The table provides an analytic crosswalk rather than a comprehensive legal inventory.

Building on these synthesis tools, the next section reports the coded cross-regime findings as diagnostic patterns, linking institutional features to widely used indicators without implying causal attribution.

## 5. Findings

The findings that follow are presented as cross-regime diagnostic patterns rather than causal estimates. The treaty profiles and indicator trends draw on synthesis assessments and widely used global indicators, and they do not allow attribution of outcome trajectories to any single agreement. The value of this approach is comparability across issue areas and identification of recurring institutional features that plausibly contribute to persistent gaps.

### *5.1. Empirical Patterns of Implementation and Enforcement*

The first key finding concerns implementation and enforcement outcomes. Across climate, biodiversity, and pollution regimes, the analysis identifies a persistent gap between negotiated commitments and realized environmental outcomes. Ambitious objectives and detailed treaty provisions have not translated into commensurate improvements in aggregate indicators such as global greenhouse gas emissions, biodiversity status, or pollution-related mortality [17,19,24,37], and regional analyses show worsening risks [15].

Evidence from biodiversity assessments shows that most state-of-biodiversity indicators either remain stable at degraded levels or continue to decline despite the proliferation of MEAs and national strategies. Climate assessments indicate that current nationally determined contributions do not yet place the world on a likely path to limiting warming to 1.5°C. Pollution studies report stagnating levels of disease burden linked to contaminated air, water, and soils. Collectively, these trends reveal an implementation and enforcement deficit that the current regime complex has not closed.

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*5.2. Empirical Patterns of Fragmentation*

The second key finding relates to institutional fragmentation. The mapping of treaties and related bodies shows that states have constructed a dense but disjointed regime complex that addresses interconnected problems through separate sectoral regimes and regional arrangements. Overlapping mandates in areas such as marine protection, chemicals management, and land-use policy generate duplicative reporting obligations and inconsistent guidance for national administrations [3,41].

Empirically, this fragmentation appears in parallel reporting streams to different MEAs, limited cross-referencing between climate and biodiversity decisions, and modest coordination between global chemicals conventions and health-focused institutions. Officials in ministries with constrained capacity must respond to multiple, partially overlapping requests for plans and reports, which can redirect resources away from implementation. The resulting patchwork undermines the coherence of national responses and complicates efforts to design integrated policies.

*5.3. Empirical Patterns of Justice and Distribution*

The third key finding concerns the distribution of environmental harms, responsibilities, and governance burdens. The evidence shows that pollution-related health impacts and vulnerability to climate and biodiversity loss concentrate disproportionately in low- and middle-income countries, while historical responsibility and financial and technological capacity remain concentrated in high-income states [1,13,19,24,27,32].

Treaty texts and COP decisions embed principles of common but differentiated responsibilities and fair and equitable benefit-sharing, yet climate finance flows and benefit-sharing outcomes remain contested and often fall short of developing countries' expectations. The GBF's participation and rights provisions have not yet translated into systematic changes in domestic legal frameworks. These empirical patterns indicate that distributive and procedural injustices persist and that they align closely with the broader implementation and coordination gaps identified above.

## 6. Discussion

*6.1. Interpreting the Findings Through Regime Complexes, Boundaries, and Justice*

The findings invite reinterpretation through the lenses of regime complexes, planetary boundaries, and environmental justice. Regime complexes can provide flexibility and adaptability compared with a single comprehensive regime [23]. The environmental regime complex has indeed fostered experimentation, as seen in the Montreal Protocol's phased schedule and the Regional Seas Program's nested structures [41,55]. However, the results here show that flexibility, when not anchored in strong coordination and enforcement mechanisms, produces a patchwork that struggles to generate system-level change.

When viewed against planetary boundaries, the regime complex appears structurally underpowered. The climate and biodiversity regimes have moved from qualitative goals to quantitative targets, including temperature limits and 30 × 30 conservation, but still rely heavily on nationally determined, non-binding contributions [6,33,35,50]. Boundary research indicates that delayed or partial action raises the risk of crossing thresholds that trigger nonlinear Earth-system responses [35]. Incremental improvements within a fragmented architecture, therefore, sit in tension with the scale and urgency of required transformations.

Environmental justice helps explain why states repeatedly choose facilitative compliance and voluntary commitments over more robust enforcement. Many developing countries reasonably view stringent obligations without corresponding finance and technology transfer as unfair; many industrialized countries fear that strong compliance systems could constrain domestic democratic choices or expose them to open-ended liabilities [27,28,32]. This configuration produces a stable but

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suboptimal equilibrium: governments accept broad commitments but design institutions that minimize short-term distributional conflict, even at the cost of long-term planetary risk.

### *6.2. Contribution*

This paper advances three contributions to debates on global environmental governance. First, it links regime complex theory directly to planetary boundaries, arguing that fragmentation and facilitative compliance do not merely create administrative inconvenience but generate a structural mismatch between institutional design and biophysical limits. The regime complex, as currently configured, lacks the integrative and enforcement capacities that a boundary-based perspective implies.

Second, the paper integrates environmental justice into the analysis of institutional performance, rather than treating it as a separate normative concern. It shows that justice disputes over finance, technology, and representation help shape regime architectures and, in turn, plausibly contribute to the implementation and enforcement gaps observed across issue areas.

Third, the paper reframes success in global environmental law. Rather than focusing on treaty proliferation or individual flagship cases such as the Montreal Protocol, it emphasizes system-level outcomes across climate, biodiversity, and pollution. On this view, success requires not only new agreements but also a reconfiguration of existing ones to prioritize implementation, coordination, and fair burden-sharing.

These contributions support a more critical and constructive research agenda that treats environmental law and politics as central determinants of whether humanity remains within a safe and just operating space.

## 7. Conclusions, Policy Implications, and Research Agenda

Implications for environmental development practice. The core contribution of this review for development-oriented scholarship and practice is the identification of recurring institutional features that influence whether global commitments translate into locally implementable policies. Underpowered compliance, fragmented mandates, and weak justice mechanisms can raise transaction costs, delay access to finance and technology, and reduce political feasibility for governments and communities facing urgent development priorities. Strengthening coordination and implementation support is therefore not only a governance reform agenda, but also a pathway to more credible, equitable, and actionable environmental development at local and regional scales. In practical terms, these governance features matter for environment and development ministries, municipal and provincial agencies, and community-based implementation actors that must translate overlapping global commitments into budgets, plans, permits, monitoring systems, and locally legitimate priorities.

### *7.1. Synthesis*

The evolution of global environmental agreements from 1971 to 2025 shows that states can recognize emerging problems, create new institutions, and achieve measurable improvements in specific domains. The recovery of the ozone layer under the Montreal Protocol and the achievements of some Regional Seas conventions demonstrate that well-designed, well-resourced MEAs can work [41,55].

At the same time, this paper's review indicates that three structural weaknesses continue to limit the regime complex's ability to stabilize the Earth system within safe bounds while advancing justice: implementation and enforcement lag behind negotiated commitments; fragmentation across treaties and scales complicates coordination and increases transaction costs; and persistent inequities in the distribution of environmental harms, responsibilities and governance burdens undermine trust and constrain the political feasibility of stronger, more binding commitments.

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These weaknesses do not erase the achievements of fifty years of environmental diplomacy. However, they suggest that further marginal expansions of the existing architecture are unlikely, by themselves, to reverse current trajectories. Transformative change will require states to reinterpret and redesign the regime complex through the combined lenses of planetary boundaries and justice [27,32].

### *7.2. Policy implications*

Several practical implications follow from this diagnosis. First, parties should prioritize implementation-focused decisions of the Conferences of the Parties. Conferences of the Parties often devote substantial effort to negotiating new declarations or work programs. A deliberate shift toward implementation, through robust national review processes, measurable milestones, peer learning, and targeted capacity-building, would better align diplomatic efforts with planetary needs.

Second, states should strengthen and rationalize compliance mechanisms. Parties can experiment with facilitation-plus models that link support to performance and introduce proportionate consequences for persistent non-compliance, such as loss of access to certain funding windows or market mechanisms. The Montreal Protocol's Multilateral Fund illustrates how states can couple finance with binding schedules [55].

Third, governments should enhance inter-regime coordination. Formal joint work programs between the UNFCCC, CBD, UNCCD, chemicals conventions, Regional Seas conventions, and the BBNJ Agreement can align reporting requirements, share data, and identify cross-cutting policy packages [41–43]. The new chemicals, waste, and pollution panel should coordinate explicitly with the IPCC and IPBES when designing assessments, to avoid duplication and exploit synergies.

Fourth, states should advance justice-oriented governance. Effective planetary governance will require more predictable climate and biodiversity finance, credible arrangements for addressing loss and damage, and stronger recognition of Indigenous and local rights. Kunming-Montreal GBF Target 23 and evolving rights-of-nature and human-rights-based approaches in national courts signal potential avenues for operationalizing these principles [6,26]. Innovative financial instruments for climate mitigation offer additional pathways for mobilizing resources, while raising questions about accountability and distribution [14].

### *7.3. Future Research*

The analysis here points to several research priorities. Comparative impact evaluations of MEAs can combine counterfactual modelling with natural experiments to estimate environmental outcomes attributable to specific agreements, building on empirical work that assesses the Montreal Protocol's climate co-benefits.

Country-level implementation studies can examine how ministries, courts, subnational governments, and civil society actors across different political economies navigate overlapping MEAs, illuminating domestic drivers of success or failure and identifying institutional designs that narrow the implementation gap. Such work would be especially valuable in contexts where development pressures, administrative constraints, and environmental vulnerability intersect most sharply.

Cross-regime interaction analysis can systematically map interactions among climate, biodiversity, ocean, and chemicals regimes to identify points where improved coordination would yield the largest gains and highlight where current overlaps do the most harm.

Integration of planetary boundaries into legal design offers another research frontier. Collaborative work between Earth-system scientists and international lawyers can explore mechanisms for embedding boundary-linked triggers in MEAs, such as automatic strengthening of commitments when monitored indicators approach critical thresholds.

Finally, scholars should advance research on justice and enforcement by designing and evaluating compliance systems that remain effective while actors perceive them as fair, particularly in finance, technology transfer, and the representation of vulnerable communities in decision-

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making. Future research should also examine how justice-oriented compliance reforms can be institutionalized without reducing participation, especially in regimes where finance, technology transfer, and representation remain politically contested [27,28].

By treating implementation, fragmentation, and justice as interconnected features of a single regime complex, rather than as separate problems, this paper argues that scholars and practitioners can reorient global environmental law toward the twin goals of ecological stability and fairness at the planetary scale.

## Appendix A. Coding Codebook and Document Sources

Appendix A summarizes the coding structure used for the qualitative comparative document analysis. The variables below define what was coded, the decision rule used to assign categories, and typical evidence sources used to support coding decisions.

| Variable | Definition and decision rule | Illustrative coding values | Primary evidence sources |
|---|---|---|---|
| Issue area | Primary environmental problem targeted by the instrument. | Climate; biodiversity; pollution or chemicals; cross-cutting | Treaty scope articles; COP mandates |
| Instrument type | Legal status and form of the regime instrument. | Treaty; protocol; COP-adopted framework; UNEA resolution | Treaty text; UN Treaty Collection; COP decision series |
| Obligation form | How commitments are expressed and whether they are schedule-based or nationally determined. | Binding phase-out schedule; quantified target; nationally determined pledge; procedural obligations | Treaty obligations; annexes; COP reporting guidance |
| Targets and timelines | Presence of explicit targets and a timetable for implementation. | Numeric target with date; qualitative target; no target | Treaty annexes; COP-adopted targets |
| Reporting and transparency | Frequency and specificity of required reporting and review. | Annual or biannual reports; enhanced transparency framework; peer review; voluntary reporting | Reporting guidelines; review procedures; national reports |
| Compliance mechanism | Existence and nature of compliance or implementation committees. | Facilitative committee; non-compliance procedure; none | Compliance procedure decisions; committee terms of reference |

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| | | | |
|---|---|---|---|
| Enforcement levers | Presence of consequences or incentives linked to compliance. | Trade measures; market access conditions; conditional finance; reputational mechanisms only | Protocol provisions; decision texts; mechanism rules |
| Finance and technology support | Dedicated funding arrangements and technology transfer provisions. | Dedicated fund; eligibility rules; capacity building programme; none | Financial mechanism decisions; operating entity guidance |
| Coordination provisions | Formal links to other regimes or joint work programmes. | Joint work programme; cross-referenced reporting; shared scientific body; ad hoc coordination | COP decisions; MoUs; joint statements |
| Justice and participation | Explicit differentiation, rights, participation, and distributional safeguards. | CBDR-style differentiation; Indigenous participation rules; gender provisions; procedural access | Preambles; operative articles; COP decisions on participation |

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