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The Structural Feasibility of Environmental Governance under Power Concentration in the Anthropocene

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The Structural Feasibility of Environmental Governance under Power Concentration in the Anthropocene

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ABSTRACT

Despite unprecedented advances in climate science, satellite monitoring, and digital environmental surveillance, global environmental degradation continues largely unabated. From climate change to deforestation and urban air pollution, improvements in knowledge and monitoring capacity have not translated into commensurate gains in governing performance. This article advances a structural explanation for this persistent gap by linking long-run environmental governability to the concentration of political-administrative power.

It develops a framework showing that environmental governance remains institutionally feasible over time only if three interdependent capacities are jointly preserved: (i) reliable transmission of environmental information, (ii) autonomous corrective accountability, and (iii) sustained political orientation toward long-term environmental protection. The central claim is that sufficiently high power concentration systematically undermines at least one of these capacities through endogenous mechanisms affecting information hierarchies, oversight autonomy, and elite selection. Once this occurs,

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governance failure becomes embedded in institutional architecture rather than remaining contingent on policy design, incentives, or declared political intentions.

The framework is situated within the Earth System Governance literature on institutional architecture, polycentricity, accountability, and information politics. Its diagnostic implications are illustrated through comparative patterns from global atmospheric governance (Montreal Protocol versus Paris Agreement), Amazon deforestation governance in Brazil, and urban air-quality governance in China. The analysis clarifies why technological advances can enhance governance performance only within structurally viable institutional configurations, and why, beyond this region of feasibility, additional monitoring, surveillance, or modeling exhibit diminishing or null returns.

By reframing environmental governance as a problem of structural feasibility under power concentration, the article contributes to current debates on the institutional conditions under which long-term environmental protection remains politically and administratively sustainable in the Anthropocene.

KEYWORDS: Environmental governance; Power concentration; Institutional feasibility; Polycentricity; Accountability; Information and monitoring; Elite selection; Anthropocene; Institutional architecture

JEL CODES

Q50 – Environmental Economics: General

Q58 – Government Policy

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1. Environmental governance under technological abundance

Despite unprecedented advances in climate science, satellite-based monitoring, and digital environmental surveillance, global environmental degradation continues largely unabated. Global greenhouse gas emissions remain incompatible with the temperature goals of the Paris Agreement, biodiversity loss is accelerating across terrestrial and marine ecosystems, and deforestation persists in critical tropical biomes. At the same time, environmental observability has never been higher: climate models, biodiversity assessments, real-time air-quality monitoring, and remote sensing now provide remarkably fine-grained representations of planetary change.

This juxtaposition reveals a central puzzle of environmental governance in the Anthropocene. Never before has humanity possessed such extensive knowledge of Earth system dynamics and such powerful technological tools for environmental monitoring—yet the capacity to translate this knowledge into sustained corrective action remains strikingly limited.

This technological–governance paradox is visible at multiple scales. In global atmospheric governance, the Montreal Protocol achieved rapid and near-universal phase-out of ozone-depleting substances under comparatively modest scientific knowledge and limited monitoring technology, whereas the Paris Agreement operates under vastly superior scientific capacity yet relies on weakly binding commitments and minimal enforcement. At the national level, Brazil’s world-leading satellite-based deforestation monitoring supported major forest loss reductions in the late 2000s, only for deforestation to surge again after 2019 despite the continued operation of the same technologies. In China, extensive air-quality monitoring has greatly increased informational visibility, yet translation into autonomous corrective action remains filtered through hierarchical political control.

Taken together, these patterns suggest that environmental governance failure cannot be understood simply as a problem of insufficient information, weak technical capacity, or incomplete regulatory coverage. Instead, they point

toward deeper structural constraints in the institutional architectures through which environmental knowledge is translated—or fails to be translated—into sustained political and administrative action.

Much of the existing literature explains environmental governance failure through problems of collective action, distributive conflict, regulatory capture, institutional fragmentation, and international free-riding. These approaches have generated powerful insights into why environmental protection is politically difficult. Yet they share a common underlying premise: that governance failure is fundamentally contingent and therefore, in principle, correctable through improved institutional design, stronger enforcement, better incentives, or greater political commitment.

This article advances a complementary and more structural claim. It argues that some configurations of political–administrative power render environmentally adequate governance systematically unreliable by design—irrespective of incentives, declared intentions, or technological endowments. Under such configurations, governance failure ceases to be primarily contingent and becomes embedded in institutional architecture itself.

The central analytical move of this article is therefore to shift attention from questions of governance optimization to questions of governance feasibility. Instead of asking only how instruments or institutional designs can be improved, it asks under what conditions environmental governance remains structurally capable of sustaining reliable information, autonomous correction, and long-term political alignment in the first place.

The article develops a structural framework that links environmental governability to the concentration of political–administrative power. Power concentration refers to the degree to which authority over three core institutional domains is vertically integrated within a narrow political center: (i) information production and aggregation, (ii) oversight and enforcement, and (iii) elite recruitment, promotion, and survival. It does not coincide with

authoritarianism per se and can arise in democracies, hybrid regimes, and international governance arrangements.

The framework identifies three interdependent governance capacities that must be jointly preserved for environmental protection to remain institutionally viable over time:

- (1) informational reliability,
- (2) corrective accountability, and
- (3) sustained political orientation toward long-term environmental protection.

The central claim is that sufficiently high power concentration tends to undermine at least one of these indispensable capacities through endogenous institutional mechanisms affecting hierarchical information transmission, organizational dependence of oversight, and elite selection dynamics. Once this occurs, environmental governance failure becomes structurally embedded in institutional architecture.

This structural perspective clarifies the conditional role of digital technologies in environmental governance. Advances in sensing, satellite monitoring, algorithmic modeling, and artificial intelligence can enhance governance performance only within institutional architectures that preserve plural information channels, autonomous oversight, and resilient political orientation. Where these conditions erode, technological advances increasingly exhibit diminishing or null returns.

The technological–governance paradox of the Anthropocene is therefore not primarily a failure of science or surveillance. It is, at its core, a problem of institutional architecture under conditions of concentrated power.

By reframing environmental governance as a problem of structural feasibility under power concentration, this article contributes to current debates in the Earth System Governance literature on institutional architecture, polycentricity, accountability, and information politics. It shifts analytical attention from governance optimization within given architectures to the

deeper architectural conditions under which long-run environmental protection remains politically and administratively sustainable in the Anthropocene.

The article proceeds as follows. Section 2 situates the framework within the Earth System Governance literature on institutional architecture, polycentricity, accountability, and information politics. Section 3 develops the structural logic of environmental governability under power concentration and formalizes the three indispensable capacities and their non-compensability. Sections 4 and 5 illustrate the diagnostic and dynamic implications of the framework through comparative patterns from global atmospheric governance, Amazon deforestation governance in Brazil, and urban air-quality governance in China, as well as through an analysis of institutional hysteresis and lock-in. Section 6 discusses the implications for polycentric and multilevel institutional design. Section 7 concludes by specifying boundary cases, scope conditions, and the non-deterministic character of the framework.

2. Power, Polycentricity, and the Structural Conditions of Environmental Governability

Environmental governance has become a central analytical domain of political science, political economy, and science and technology studies in the Anthropocene. Research converges on the recognition that planetary-scale environmental problems cannot be governed through traditional regulatory instruments alone, but require complex institutional arrangements integrating multiple levels of authority, diverse actors, and heterogeneous knowledge systems (Biermann et al., 2009; Young, 2017; Biermann & Kim, 2020). Within this broad literature, three strands are particularly relevant for developing a structural perspective on environmental governability: (i) the Earth System Governance (ESG) literature on institutional architecture and polycentricity, (ii) the literature on accountability and enforcement, and (iii) the literature on information, expertise, and technological governance. The framework

developed here connects these strands through a unified focus on the feasibility conditions of governance under power concentration.

2.1 Earth System Governance and Institutional Architecture

The Earth System Governance research program emphasizes that environmental problems in the Anthropocene require forms of governance that transcend the nation-state and integrate authority across local, national, regional, and global levels (Biermann et al., 2009; Young, 2017). Central to this perspective is the concept of institutional architecture: the configuration of rules, organizations, and authority relations that structure governance across scales (Biermann & Kim, 2020).

Within this tradition, polycentric governance has emerged as a key analytical reference point. Building on Ostrom (2010), polycentricity denotes systems characterized by multiple overlapping centers of authority operating with some degree of autonomy within a shared rule system. Such arrangements are often associated with experimentation, learning, and adaptability under conditions of complexity and uncertainty (Jordan et al., 2018; Stevenson & Dryzek, 2014).

At the same time, ESG scholars have consistently warned against overly optimistic readings of polycentricity. Fragmentation, overlapping mandates, power asymmetries, and weak coordination can undermine policy coherence and political accountability (Abbott et al., 2015; Young, 2017). Recent work has therefore shifted from celebrating polycentricity as such toward analyzing the conditions under which multi-level systems remain governable, legitimate, and accountable over time (Biermann & Gupta, 2011; Newell, 2012).

The present article contributes to this debate by introducing a structural threshold perspective. Rather than treating polycentricity and centralization as alternative institutional designs to be balanced through empirical trade-offs, it asks whether there exist levels of power concentration beyond which core

governance capacities become systematically unreliable, regardless of fine-tuning within a centralized architecture.

2.2 Accountability, Enforcement, and Institutional Control

A second major strand of environmental governance research concerns accountability and enforcement. A large empirical literature documents persistent enforcement gaps at both national and international levels (Jänicke & Jörgens, 2006; Mitchell, 2008; Andrews et al., 2017). These gaps are commonly attributed to limited monitoring capacity, political interference, regulatory capture, weak sanctioning powers, and misaligned incentives within implementing agencies (Newell, 2012; Aklin & Mildemberger, 2020). At the international level, the absence of centralized coercive authority has long been seen as a structural obstacle to effective enforcement (Keohane & Victor, 2011; Victor et al., 2019).

While this literature offers detailed diagnoses of why enforcement fails in specific contexts, it typically treats failure as a contingent political outcome. The structural perspective developed here complements this view by highlighting a deeper mechanism: as appointment authority, budgetary control, and career incentives within oversight institutions become increasingly centralized, the long-run functional autonomy of enforcement tends to erode endogenously, even in the absence of overt legal dismantling or systematic corruption.

From this viewpoint, the weakening of environmental enforcement does not require explicit institutional destruction. It can occur through gradual organizational dependence, internal selection dynamics, and the reorientation of professional incentives within hierarchical administrative systems. This shifts the analytical focus from episodic political interference to the architectural conditions under which correction remains structurally viable.

2.3 Information, Expertise, and Technological Optimism

A third strand of scholarship addresses the role of information, expertise, and digital technologies in environmental governance. Advances in satellite monitoring, big data, and algorithmic modeling have fueled expectations that enhanced observability and predictive capacity can overcome traditional governance obstacles (Mol, 2011; Gupta et al., 2014). Transparency initiatives, open data platforms, and real-time monitoring systems are often presented as tools for strengthening accountability, participation, and policy responsiveness.

At the same time, a substantial body of critical scholarship emphasizes the political nature of environmental information. Knowledge is filtered, framed, and selectively mobilized within institutions structured by power (Jasanoff, 2004; Turnhout et al., 2019). Informational abundance does not automatically translate into political action.

The structural perspective developed here builds on this insight by emphasizing that the architecture of information transmission matters as much as, if not more than, the volume of available data. As reporting chains become increasingly hierarchical, the institutional distance between ecological reality and collective decision-making tends to grow. Under such conditions, additional data can coexist with increasing informational distortion at the center, helping to explain why technological advances in monitoring often fail to produce proportional improvements in environmental outcomes.

2.4 Power, Elites, and Preference Alignment

Environmental governance also depends critically on the orientation of governing elites toward long-term ecological protection. Political sociology and political economy have long examined how elite recruitment, survival, and circulation shape policy outcomes (Michels, 1915; Mosca, 1939; Acemoglu & Robinson, 2012). More recent work has explored how environmental policy is

shaped by elite coalitions, business interests, and intertemporal political incentives (Newell & Paterson, 2010; Jacobs, 2016).

Much of this literature focuses on who holds power rather than on how the structure of power concentration itself reshapes elite preferences over time. Centralization affects not only what elites can do, but also which types of elites survive and advance within governing institutions. As authority becomes more concentrated, political loyalty and narrative conformity tend to become more decisive for career survival than long-term environmental performance. Over time, this can generate a cumulative drift in the composition of governing elites, even in the absence of abrupt ideological change.

This insight connects environmental governance to broader debates on executive aggrandizement and democratic backsliding (Bermeo, 2016; Levitsky & Ziblatt, 2018), while highlighting its direct implications for long-run environmental protection.

2.5 From Governance Optimization to Governance Feasibility

Taken together, the literatures on polycentric governance, accountability and enforcement, information politics, and elite selection have generated a powerful understanding of why environmental governance is difficult in the Anthropocene. What they have less clearly articulated is the possibility that some institutional architectures may lie beyond the feasible set of environmental governance altogether, rather than merely embodying less efficient or more conflictual trade-offs.

The structural perspective developed in this article reframes the problem from one of governance optimization to one of governance feasibility. Instead of asking how decentralized and centralized elements can be optimally combined, it asks whether there exist configurations of authority in which one or more indispensable governance capacities become systematically unreliable, regardless of incremental reforms within the same architecture.

This reframing does not deny the importance of incentives, legitimacy, political conflict, or institutional design. It instead places them within a deeper architectural layer: the distribution and concentration of power across information, oversight, and elite selection. The next section formalizes this perspective by introducing a structural framework of environmental governability under power concentration and by specifying the three core capacities whose joint preservation is required for long-run environmental protection to remain institutionally viable.

3. The Structural Framework: Environmental Governability under Power Concentration

This section develops the structural framework that links environmental governability to the concentration of political-administrative power. The framework is deliberately non-formal and non-technical. Its objective is not to provide quantitative thresholds or predictive models, but to clarify the institutional mechanisms through which power concentration reshapes the feasibility conditions of environmental governance over time.

3.1 Power Concentration as an Architectural Variable

Power concentration refers to the degree to which authority over three core domains is vertically integrated within a narrow political-administrative center:

information production and aggregation,

oversight and enforcement,

elite recruitment, promotion, and survival.

Power concentration does not coincide with authoritarianism per se, nor with regime type. Highly centralized configurations of power can emerge within:

formally democratic systems,

hybrid regimes,

and international governance arrangements.

In ideal-typical terms, low power concentration is associated with:

multiple autonomous information channels,

decentralized or pluralized oversight institutions,

diversified elite recruitment pathways.

By contrast, high power concentration is associated with:

hierarchical information aggregation,

vertically subordinated oversight bodies,

and centralized control over elite appointment, promotion, and replacement.

Crucially, power concentration is treated here as an architectural property of institutional design, not as an attribute of individual leaders. The framework abstracts from ideology, competence, or moral intentions and focuses instead on how authority is structurally distributed across the institutional system.

3.2 Three Indispensable Capacities of Environmental Governance

The framework rests on the claim that environmentally adequate governance requires the joint preservation of three structurally distinct capacities. Each is individually necessary; none is sufficient on its own.

(i) Informational Reliability

Environmental governance requires the capacity to form sufficiently reliable knowledge of aggregate environmental states: pollution levels, deforestation trends, ecosystem degradation, hydrological stress, and climatic risks. This capacity depends not only on the availability of raw data, but on the

institutional structure of information transmission from dispersed ecological signals to collective decision-making arenas.

Plural and partially redundant information channels are essential. They allow:

error detection,

signal comparison,

and the correction of localized distortions.

As power concentration rises, these capacities do not deteriorate gradually and independently. Rather, rising concentration tends to generate structural fragility zones in which at least one core capacity becomes systematically unreliable.

(ii) Corrective Accountability

Environmental governance requires the capacity to detect, report, and sanction failures of implementation: illegal emissions, regulatory non-compliance, under-enforcement, and administrative collusion. This capacity depends on the functional autonomy of oversight institutions, not merely on their formal legal status.

Corrective accountability presupposes that inspectors, regulators, auditors, and courts are organizationally insulated from those whose actions they evaluate. Where enforcement agencies become structurally dependent on centralized political authority for:

appointments,

promotions,

and budgets,

their probability of triggering politically consequential correction tends to erode over time—even without any explicit change in the law.

(iii) Sustained Orientation toward Long-Term Environmental Protection

Finally, environmental governance requires a minimal degree of alignment between the effective preferences of governing elites and the long-term protection of ecological systems. This does not require altruism or green ideology. It requires that environmentally destructive outcomes impose institutional, political, or reputational costs on those who exercise authority.

This capacity depends on the structure of elite recruitment, survival, and promotion. Where career survival becomes primarily dependent on:

political loyalty,

narrative alignment,

and organizational adaptability,

long-run environmental performance tends to become progressively decoupled from elite incentives.

3.3 Endogenous Erosion under Rising Power Concentration

The central structural claim of the framework is that rising power concentration tends to undermine the three capacities through endogenous institutional mechanisms. These mechanisms do not require corruption, censorship, ideological hostility to environmental protection, or legal breakdown. They operate through ordinary organizational dynamics.

Informational Compression

As authority becomes more centralized, information increasingly flows through hierarchical reporting chains. Independent channels are merged,

subordinated, or eliminated. Signals are aggregated earlier and transmitted through fewer institutional nodes. Even under conditions of:

formal transparency,

open data,

and legal reporting obligations,

the institutional diversity of signals that effectively reach decision-makers tends to shrink.

The result is a growing institutional distance between ecological reality and collective decisions. Informational errors become systemic rather than idiosyncratic.

Organizational Dependence of Oversight

Centralization reshapes the internal dynamics of enforcement institutions. As appointment and replacement authority becomes concentrated, organizational survival within oversight bodies becomes progressively linked to alignment with the political center rather than to corrective performance. Over time, this weakens the probability that serious environmental failures are detected and acted upon in a politically consequential way.

This mechanism does not require overt repression, censorship, or shielding of violators. It operates through ordinary administrative incentives in centralized hierarchies.

Preference Drift in Elite Selection

Finally, power concentration reshapes elite selection itself. Governing elites who are less adaptable to centralized control, less aligned with dominant political narratives, or more protective of long-term constraints tend to face

systematic survival disadvantages. Over time, this generates a cumulative drift in the composition of governing elites, even in the absence of abrupt ideological shifts or constitutional change.

The resulting misalignment between elite incentives and long-term environmental protection is therefore structural rather than episodic.

3.4 Structural Non-Compensability

A defining implication of the framework is that the three governance capacities are not fully compensable. Informational transparency cannot substitute for corrective accountability, strong formal enforcement cannot offset sustained preference drift, and technological optimization cannot restore autonomous oversight. In sufficiently centralized configurations, governance failure persists not because all functions collapse simultaneously, but because the structural unreliability of a single indispensable capacity neutralizes improvements along the others.

3.5 Technology and Conditional Effectiveness

The framework clarifies the conditional role of digital technologies in environmental governance. Advances in sensing, satellite monitoring, algorithmic modeling, and artificial intelligence can enhance governance performance only within institutional architectures that preserve plural information channels, autonomous oversight, and resilient political orientation. Beyond this region of structural viability, additional sensors, surveillance, or algorithms cannot restore independent information flows, autonomous correction, or long-term political alignment, and technology becomes institutionally neutralized.

3.6 From Governance Optimization to Governance Feasibility

Taken together, these mechanisms imply a shift in analytical perspective. Much of the existing literature asks how environmental governance can be optimized under given institutional constraints. The present framework instead asks under what conditions environmental governance remains feasible at all as a sustained institutional enterprise.

Once one of the three indispensable capacities becomes structurally unreliable, governance failure ceases to be mainly a problem of insufficient effort, weak design, or adverse incentives. It becomes embedded in institutional architecture itself. This logic provides the conceptual foundation for the diagnostic and dynamic analysis developed in the following sections.

3.7 Visual Orientation (Figure Placement)

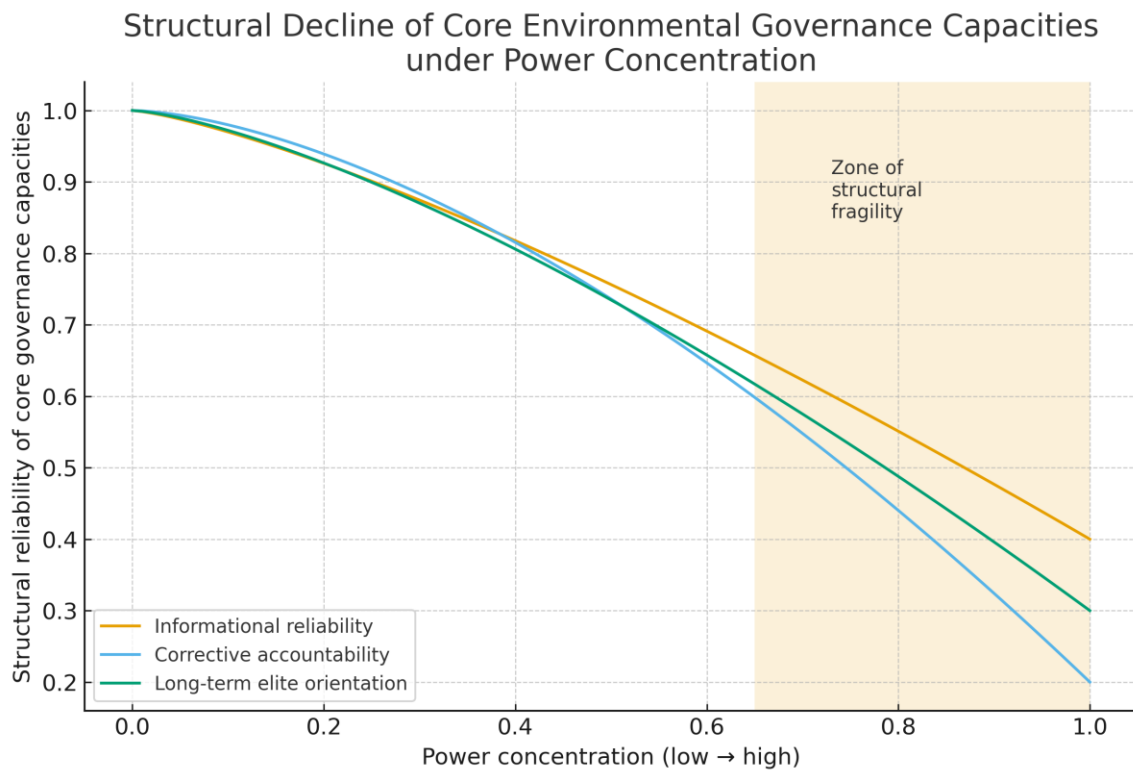


Figure 1. *Structural decline of core environmental governance capacities under rising power concentration.* The figure provides a conceptual visualization of how three indispensable capacities of long-run environmental governance—informational reliability, corrective accountability, and sustained elite orientation toward long-term

environmental protection—tend to deteriorate as political-administrative power becomes increasingly concentrated. The shaded area denotes a zone of heightened structural fragility in which at least one of these non-substitutable capacities becomes systematically unreliable, so that governance failure becomes embedded in institutional architecture rather than remaining contingent on policy design, incentives, or technological endowments. The curves are illustrative and do not represent empirical estimates.

4. Structured Diagnostic Patterns

This section illustrates the diagnostic logic of the structural framework through three comparative governance patterns:

- (i) global atmospheric governance (Montreal Protocol versus Paris Agreement),
- (ii) Amazon deforestation governance in Brazil, and
- (iii) urban air-quality governance in China.

These cases are not presented as formal tests of the framework, nor as exhaustive empirical reconstructions. Their purpose is diagnostic: to assess whether observed governance trajectories are consistent with the structural mechanisms outlined in Section 3, especially the interaction between informational reliability, corrective accountability, and elite orientation under different configurations of power concentration.

4.1 Global Atmospheric Governance: Montreal versus Paris

The contrast between the Montreal Protocol on Substances that Deplete the Ozone Layer and the Paris Agreement on climate change remains one of the most instructive puzzles in global environmental governance. The Montreal Protocol, adopted in 1987 and repeatedly strengthened thereafter, is widely regarded as the most successful global environmental treaty ever implemented (Andersen et al., 2007; EEAP, 2018). It achieved near-universal participation, rapid phase-out of ozone-depleting substances, and measurable recovery trends in the ozone layer.

By contrast, the Paris Agreement, adopted in 2015, operates under vastly superior scientific knowledge, global monitoring infrastructure, and public awareness (IPCC, 2023). Yet it relies almost entirely on nationally determined contributions (NDCs), lacks binding enforcement mechanisms, and remains structurally dependent on voluntary compliance (Bodansky, 2016; Victor et al., 2019). The resulting global emissions trajectory remains inconsistent with the Agreement's stated temperature objectives (UNEP, 2023).

From the structural perspective developed in this article, this contrast cannot be explained primarily by differences in information or technology. Instead, it reflects a sharp divergence in the architecture of corrective accountability. The Montreal regime combined centralized agenda-setting with:

legally binding domestic implementation,

trade-based sanctions,

and a relatively insulated scientific assessment process.

These institutional features preserved a non-trivial degree of autonomous corrective capacity across jurisdictions, even in the absence of a global sovereign.

The Paris regime, by contrast, exhibits strong symbolic centralization at the level of global agenda-setting combined with extreme decentralization of enforcement. There is no autonomous international mechanism capable of imposing material sanctions for non-compliance. Corrective accountability is reabsorbed into heterogeneous national political cycles, which vary widely in their capacity to sustain long-term climate commitments. The result is a structurally weak correction environment despite unprecedented informational abundance.

This case exemplifies the principle of structural non-compensability: superior monitoring and scientific precision do not compensate for the absence of autonomous corrective institutions. Informational reliability at the global level coexists with endemic corrective fragility.

4.2 Amazon Deforestation Governance in Brazil

Brazil provides one of the clearest real-world illustrations of the interaction between monitoring technology, enforcement autonomy, and political support. Since the mid-2000s, Brazil has operated some of the most advanced satellite-based deforestation monitoring systems in the world, notably PRODES (annual high-resolution monitoring) and DETER (near real-time detection) (Assunção et al., 2015; INPE, 2023).

Between approximately 2005 and 2012, Amazon deforestation declined by more than 80 percent. This decline coincided with:

expansion of protected areas,

strengthened enforcement by IBAMA and the Federal Police,

credit and commodity embargoes,

and strong presidential-level political backing (Nepstad et al., 2014; Assunção et al., 2015).

During this phase, informational capacity, corrective accountability, and elite orientation were temporarily aligned within a hybrid but still partially pluralized institutional architecture.

After 2019, deforestation rose sharply again. Crucially, this reversal occurred while the same monitoring technologies remained fully operational. What changed was the organizational and political environment of correction. Environmental agencies experienced:

budgetary contraction,

leadership replacement,

public delegitimation,

and systematic weakening of enforcement operations (Ferrante & Fearnside, 2019).

From a structural standpoint, this trajectory is consistent with a shift in the balance between informational reliability and corrective accountability. Informational capacity remained high, but the institutional conditions required to transform information into politically consequential correction deteriorated. Monitoring alone proved insufficient to stabilize outcomes once organizational dependence of oversight and political de-alignment set in.

The Brazilian case thus illustrates the principle of conditional technological effectiveness: the technology did not fail; the institutional architecture enabling its governing effectiveness did.

4.3 Urban Air-Quality Governance in China

China has constructed one of the most extensive air-quality monitoring networks in the world since the early 2010s. Thousands of ground-based monitoring stations now provide real-time public data on particulate matter (PM2.5), sulfur dioxide, nitrogen oxides, and ozone across major urban areas (Li et al., 2012; Fu et al., 2021). This represents a dramatic increase in informational visibility relative to earlier periods.

There is robust evidence that air quality in several major Chinese urban regions improved during the mid- to late 2010s, particularly with respect to particulate pollution. These improvements were driven by centrally mandated targets, cadre evaluation reforms, and massive investment in pollution control.

At the same time, the translation of information into autonomous corrective accountability remains structurally constrained. Enforcement is embedded within a hierarchical performance-management system in which:

local officials are evaluated on centrally defined indicators,

reporting remains politically filtered,

and corrective action remains administratively subordinate (Li et al., 2012; Kostka & Zhang, 2018).

From the structural perspective, China illustrates a configuration in which informational capacity expands rapidly under sustained political centralization, while corrective accountability remains internally subordinated to the same hierarchy that defines political survival. This produces:

short- and medium-term performance improvements,

combined with persistent structural vulnerability to indicator gaming, selective enforcement, and reprioritization.

Unlike the Brazilian case, where corrective autonomy eroded after previously existing, the Chinese case exhibits selective effectiveness without autonomous correction from the outset. Unlike the climate regime, where enforcement is structurally absent, China exhibits enforcement that is present but hierarchically absorbed.

4.4 Cross-Case Diagnostic Implications

Taken together, the three cases display contrasting constellations of the three governance capacities:

Montreal versus Paris: strong informational capacity in both, but radically different corrective architectures.

Brazil: persistent informational capacity combined with endogenous erosion of corrective autonomy and elite orientation.

China: expanding informational visibility under sustained centralized performance management with hierarchically absorbed correction.

None of these cases can be adequately explained by monitoring technology alone. Instead, their trajectories reflect distinct architectures of information

transmission, enforcement autonomy, and elite orientation, as emphasized by the framework.

The cases also underscore that centralized systems may generate selective and reversible environmental success rather than sustained environmental governability. Where performance depends heavily on hierarchical political alignment rather than on autonomous correction and plural information channels, governance outcomes remain structurally fragile under shifting political priorities.

These comparative patterns motivate the dynamic extension of the framework developed in the next section: the analysis of institutional hysteresis, lock-in, and recovery constraints under power concentration.

5. Institutional Hysteresis, Lock-In, and Recovery Constraints

The structural framework developed in the previous sections has a fundamentally dynamic implication: the deterioration of core governance capacities under high power concentration is not symmetrically reversible. Once informational reliability, corrective accountability, or long-term political orientation erode beyond a certain point, the institutional conditions required for their restoration tend to be weakened by the very same processes that produced the initial erosion. This section conceptualizes this asymmetry as a form of institutional hysteresis and examines the resulting risks of lock-in into chronically underperforming governance regimes.

5.1 Hysteresis in Core Governance Capacities

Hysteresis refers to situations in which the path of decline and the path of recovery are not equivalent. In the context of environmental governance, it denotes the fact that the loss of institutional capacity under power

concentration typically occurs faster and more easily than its subsequent reconstruction.

Three interrelated forms of institutional hysteresis follow directly from the mechanisms identified in Section 3.

Informational Hysteresis

As plural information channels are compressed into hierarchical reporting pipelines, the organizational routines, professional norms, networked practices, and trust relations that once supported decentralized knowledge production tend to dissolve. Even if formal decentralization is later reintroduced, the informational ecosystem does not automatically regenerate. Independent expertise, reporting infrastructures, and institutionalized dissent require time, protection, and political support to re-emerge.

As a result, informational reliability often remains depressed long after formal reforms aimed at reopening information channels have been adopted.

Corrective Hysteresis

Once oversight institutions become organizationally dependent on centralized appointment authority, budgetary control, and career incentives, their internal selection dynamics change endogenously. Personnel composition, professional expectations, and organizational cultures adapt to the new environment. Over time, this results in:

lower tolerance for confrontational enforcement,

internalization of political risk-avoidance,

and weakened professional autonomy.

Restoring corrective accountability under such conditions requires not only legal reform but a deep transformation of organizational incentives and cultures, which typically unfolds slowly and unevenly.

Preference Hysteresis

When elite survival becomes progressively detached from long-term environmental performance, the composition of governing elites drifts accordingly. Even if political rules are later liberalized or formal accountability institutions are restored, the available pool of experienced decision-makers may already be structurally biased toward short-term political survival logics.

Reorienting elite incentives under such conditions often requires generational turnover, not merely procedural reform. This introduces a temporal delay that is particularly consequential for environmental problems governed by ecological thresholds and irreversibilities.

5.2 Lock-In under High Power Concentration

Institutional hysteresis creates the structural conditions for lock-in. Lock-in does not imply total governance paralysis. Rather, it denotes a condition in which governance operates at a persistently reduced level of structural capacity that becomes increasingly self-reinforcing over time.

Lock-in emerges through several mutually reinforcing feedback mechanisms:

Informational Feedbacks

Hierarchical information systems tend to reproduce themselves. Data-collection priorities, reporting formats, and performance indicators are standardized from the top down. Alternative knowledge channels—such as civil-society monitoring, independent scientific dissent, or local experiential knowledge—lose institutional traction, making future diversification progressively more difficult.

Organizational Feedbacks

Oversight bodies that become dependent on centralized appointment and budgetary control tend to attract individuals who are comfortable operating under such conditions. Over time, recruitment pools, career expectations, and professional identities adapt to the new environment, reinforcing organizational dependence even in the absence of overt political pressure.

Political Feedbacks

As environmental policy becomes increasingly filtered through short-term political survival logics, long-term ecological concerns are more easily reframed as obstacles to growth, stability, or control. This framing then justifies further concentration of authority in the name of coordination, efficiency, or crisis management—deepening the original condition.

Through these feedbacks, high power concentration can generate a self-stabilizing low-governability equilibrium: environmental outcomes remain persistently misaligned with ecological dynamics, yet institutional reform becomes progressively harder to initiate and sustain.

5.3 Institutional Irreversibility and Ecological Irreversibility

The risks of hysteresis and lock-in are particularly acute in the environmental domain because many ecological systems exhibit biophysical irreversibilities and non-linear threshold dynamics. Climate change, biodiversity loss, deforestation, soil degradation, and hydrological disruption frequently involve tipping points after which recovery becomes either impossible or dramatically more costly (Rockström et al., 2009; Steffen et al., 2018).

This creates a dangerous interaction between:

institutional irreversibility, driven by power concentration and hysteresis,

and ecological irreversibility, driven by Earth system dynamics.

Even if institutional recovery eventually becomes politically feasible, it may occur too late to prevent irreversible ecological transformations. In this sense, the structural limits of environmental governance under power concentration are not merely an administrative or political concern. They directly shape the long-term biophysical trajectory of the Earth system.

This interaction also helps to explain the persistent gap between the urgency expressed in scientific assessment reports and the sluggishness of institutional response. When informational reliability, corrective accountability, or elite orientation deteriorate structurally, urgency can be recognized discursively without being translated into sustained corrective capacity.

5.4 Why Incremental Reform Often Fails

A central implication of the hysteresis perspective is that incremental institutional reform is frequently insufficient once structural erosion has progressed beyond a certain point. Efforts to improve monitoring technology, refine enforcement rules, or create new coordinating bodies tend to be absorbed by existing organizational logics rather than transforming them.

Repeated reform cycles in highly centralized systems often produce characteristic symptoms:

proliferation of targets without enforcement,

transparency without accountability,

and ambition without durability.

Such patterns are frequently misinterpreted as mere failures of political will or bureaucratic competence. From a structural viewpoint, they reflect the fact that reforms operate within an architectural configuration that has already crossed a viability threshold for at least one core governance capacity.

5.5 The Preventive Logic of Institutional Design

The foregoing analysis implies a preventive logic for environmental institutional design. The most consequential choices for long-run environmental governability are often not choices about policy instruments, emission targets, or regulatory stringency. They are architectural choices about:

who controls information flows,

who appoints and disciplines oversight institutions,

and how elites enter, survive, and exit positions of authority.

Once hysteresis has taken hold, recovery requires disproportionately greater political effort, institutional reconstruction, and social mobilization than would have been required to prevent the initial erosion. In the Anthropocene, where ecological systems exhibit threshold dynamics and irreversibilities, delayed institutional recovery may arrive too late to stabilize critical components of the Earth system.

From this perspective, institutional architecture is not a neutral background condition of environmental policy. It is a first-order determinant of whether environmental governance remains feasible at all under conditions of accelerating biophysical change.

6. Institutional Design Implications for Polycentric and Multilevel Governance

The structural framework developed in this article does not prescribe specific policy instruments, regulatory standards, or technological solutions. Instead, it identifies a set of architectural conditions that shape whether environmental governance remains institutionally feasible over time. These conditions operate at a deeper level than individual policies: they concern how power, information, oversight, and elite selection are distributed across governance systems.

This section draws out the main implications of the framework for the design of polycentric and multilevel environmental governance architectures under conditions of deep uncertainty, ecological irreversibility, and political volatility.

6.1 Polycentricity as a Structural Safeguard, Not a Panacea

The Earth System Governance literature has long emphasized the potential advantages of polycentric governance, including experimentation, learning, redundancy, and adaptability (Ostrom, 2010; Jordan et al., 2018; Stevenson & Dryzek, 2014). The structural framework developed here supports this emphasis—but for a more fundamental reason.

Polycentricity matters not only because it may improve efficiency, participation, or innovation, but because it functions as a structural safeguard against the simultaneous erosion of all three core governance capacities:

It preserves plural information channels, reducing the risk of correlated informational failure.

It limits the organizational absorption of oversight by any single political center.

It sustains diversified elite recruitment pathways, constraining cumulative preference drift.

From this perspective, polycentricity is not merely one design option among others to be optimized through trade-offs. It is a risk-management strategy aimed at preventing governance architectures from drifting into zones of structural fragility.

At the same time, the framework also clarifies why polycentricity is not a panacea. Fragmentation without coordination can produce regulatory arbitrage, responsibility diffusion, and policy gridlock (Abbott et al., 2015; Young, 2017). The implication is therefore not to maximize polycentricity as

such, but to avoid extreme centralization across all three architectural dimensions simultaneously.

6.2 Autonomous Oversight as an Architectural Requirement

A second core implication concerns the institutional design of environmental oversight. The framework suggests that formal independence is insufficient if organizational dependence persists through centralized appointment authority, budgetary leverage, or hierarchical performance management.

From a structural perspective, the key requirement is not independence in statute alone, but the organizational resilience of corrective institutions. This includes:

diversified appointment procedures,

multi-source budgeting,

protection for dissenting enforcement officials,

judicial insulation from executive reprisal,

and professional standards that cannot be overridden through administrative fiat.

These features do not guarantee effective enforcement. But without them, corrective accountability becomes structurally vulnerable to absorption under power concentration. The Brazilian deforestation case illustrates how rapidly enforcement capacity can erode once organizational dependence deepens, even when monitoring technology remains intact.

6.3 Plural Elite Recruitment and the Long-Term Orientation Problem

Environmental governance is unusually sensitive to intertemporal political inconsistency. Climate mitigation, biodiversity protection, and ecosystem

restoration impose costs in the present while generating benefits in the future. This makes elite orientation a central structural variable.

The framework highlights the importance of plural elite recruitment and survival channels as a safeguard against cumulative preference drift. These include:

competitive electoral pathways,

professional bureaucratic careers with merit-based promotion,

judicial and regulatory careers insulated from political turnover,

transnational professional networks in science, law, and administration.

Where such channels remain diversified, the composition of governing elites is less likely to converge toward purely survival-oriented types. Where they collapse into a single centralized pipeline, long-term environmental orientation becomes structurally fragile, regardless of the declared preferences of political leaders.

This insight reframes debates on executive aggrandizement, democratic backsliding, and bureaucratic politicization (Bermeo, 2016; Levitsky & Ziblatt, 2018) as not only threats to democratic governance, but as direct structural risks to long-run environmental protection.

6.4 Technology Policy as Institutional Policy

A recurring implication of the framework is that technology policy and institutional design cannot be separated. Investments in satellite monitoring, algorithmic enforcement, digital reporting, and artificial intelligence are often justified in purely technical or efficiency-oriented terms. From a structural perspective, their governing effectiveness is conditional on the architecture into which they are embedded.

This implies that technology policy should be evaluated *ex ante* in terms of:

whether it reinforces hierarchical information bottlenecks or plural knowledge channels,

whether it strengthens autonomous correction or merely top-down surveillance,

whether it empowers diversified decision-makers or centralizes discretionary control.

Without such evaluation, technology risks becoming a force multiplier of existing institutional fragilities rather than a remedy for them. This helps to explain why increased monitoring frequently coexists with persistent or even worsening governance failure under concentrated power.

6.5 Multilevel Governance and Structural Spillovers

Environmental governance increasingly operates across multiple jurisdictional scales—local, national, regional, and global. Multilevel governance is often seen as a mechanism for reconciling local diversity with global coordination (Biermann et al., 2009; Hooghe & Marks, 2003).

The structural framework developed here suggests that power concentration at one level can spill over into others. For example:

Global agenda-setting without autonomous national enforcement produces persistent corrective fragility, as in the climate regime.

National-level executive concentration can neutralize local monitoring and enforcement even where formal decentralization persists.

Central control over elite recruitment can reshape judicial, regulatory, and scientific institutions simultaneously.

This implies that structural vulnerability is often cross-scalar. Assessing the governability of a multilevel environmental system therefore requires tracing

how concentration or dispersion at one level reshapes core capacities at other levels.

6.6 A Preventive Orientation to Institutional Design

Taken together, these implications converge on a preventive orientation to environmental institutional design. The most decisive choices for long-run environmental governability are often not choices about emission targets, policy instruments, or regulatory stringency. They are architectural choices about:

who controls information flows,

who appoints and disciplines oversight bodies,

and how elites enter, survive, and exit positions of authority.

Once these design choices generate cumulative erosion along one or more of these dimensions, incremental correction becomes increasingly difficult, as shown by the hysteresis dynamics discussed in Section 5. Preventive institutional design therefore becomes a core component of environmental policy itself—not a background constitutional issue.

7. Scope Conditions, Boundary Cases, Structural Counterexamples, and Conclusion

The structural framework developed in this article reframes environmental governability as an architectural problem of institutional feasibility under power concentration. Rather than treating governance failure primarily as a consequence of weak incentives, limited political will, or insufficient technological capacity, the analysis has shown how the long-run viability of environmental governance depends on the joint preservation of three indispensable capacities: informational reliability, corrective accountability,

and sustained political orientation toward long-term environmental protection. This final section clarifies the domain of validity of the framework, its boundary conditions, the circumstances under which it may be empirically weakened or falsified, and the broader implications for environmental governance in the Anthropocene.

7.1 Domain of Structural Validity

The framework is intended to apply primarily to environmental governance systems that exhibit three baseline characteristics.

First, it targets high-complexity environmental problems with long time horizons, such as climate change, biodiversity loss, deforestation, large-scale air and water pollution, and land and soil degradation. These problems are characterized by delayed feedbacks, cumulative effects, and partial irreversibilities.

Second, it presupposes multi-level institutional organization, in which information, rule-making, and enforcement are distributed across local, national, and often transnational governance levels.

Third, it assumes at least partial functional differentiation between knowledge production, political decision-making, and implementation, even where these functions are closely coordinated.

Within this domain, the framework advances a claim about structural feasibility, not about policy optimization. It specifies the institutional conditions under which environmental governance tends to become systematically unreliable regardless of policy instruments, stated intentions, or technological sophistication. The argument is therefore not regime-specific. It applies, in principle, to authoritarian systems, centralized democracies, and highly centralized configurations of international governance alike. What matters is not regime label, but the degree of vertical integration of authority over information, oversight, and elite survival.

7.2 Boundary Cases and Limited Domains

The framework is not designed to explain all forms of environmental governance failure. Its explanatory power is restricted in several boundary domains.

(i) Low-Complexity, Short-Feedback Environmental Problems

Where environmental externalities are local, causal chains are short, and corrective feedback is rapid—such as in many forms of municipal waste management, point-source water pollution, or localized industrial accidents—high power concentration does not necessarily undermine governability. In such settings, informational, corrective, and preference-alignment pressures are structurally less demanding.

(ii) Short-Term Emergency Governance

Under acute environmental emergencies—industrial disasters, wildfire outbreaks, toxic releases—temporary centralization may enhance coordination speed and crisis response. The framework does not deny this. Its claim concerns long-run institutional viability, not short-run crisis command. Structural fragility emerges when emergency centralization becomes a durable governance architecture rather than an exceptional response.

(iii) Narrow Authoritarian Performance Regimes

Some highly centralized systems may achieve selective and reversible environmental success when performance is measured through a narrow set of centrally enforced indicators, political incentives are tightly aligned with those indicators, and the time horizon remains short to medium term. The Chinese air-quality case illustrates this pattern. The framework does not

predict universal failure under centralization, but rather heightened long-term vulnerability to reprioritization, indicator gaming, and policy reversal.

7.3 Conditions under Which the Framework May Be Weakened

The framework rests on several structural assumptions. If these assumptions do not hold, its conclusions may not apply.

(i) Robust Non-Hierarchical Information Channels under Centralization

If genuinely independent scientific institutions, autonomous civil-society monitoring, and legally protected media ecosystems remain institutionally insulated from hierarchical absorption even under high political centralization, informational reliability may remain structurally resilient beyond what the framework predicts. Such configurations are empirically rare but not conceptually impossible.

(ii) Hard Constitutional Protection of Oversight Institutions

If oversight bodies enjoy constitutionally entrenched independence, irreducible multi-source budgeting, and strong judicial protection for enforcement officials, corrective accountability may resist organizational dependence even under high executive concentration. In this case, one of the three core erosion mechanisms would be structurally blocked.

(iii) Externally Enforced Preference Alignment

The framework assumes that elite orientation is primarily shaped by domestic political survival. This assumption weakens where binding external constraints—such as trade sanctions, financial conditionality, or supranational legal authority—directly tie elite survival to long-term environmental

performance. Under such conditions, preference drift may be partially offset from outside the system.

7.4 Non-Determinism and Empirical Falsifiability

The framework is explicitly non-deterministic. It does not claim that every centralized system must fail environmentally, nor that decentralization guarantees success. Instead, it advances a probabilistic structural claim:

As political-administrative power becomes sufficiently concentrated across information, oversight, and elite selection, the probability that at least one indispensable governance capacity becomes systematically unreliable rises sharply and non-linearly.

The framework would be empirically weakened by sustained observations of governance systems that simultaneously exhibit:

persistent high power concentration,

long-term informational reliability,

autonomous corrective accountability,

and stable elite orientation toward long-run environmental protection,

across multiple political cycles and environmental domains. Such cases would constitute genuine structural counterexamples to the argument advanced here.

7.5 Structural Contingency and the Limits of Incentive-Based Explanations

The framework is not a substitute for incentive-based, ideological, or conflict-centered theories of environmental politics. Instead, it operates at a deeper architectural layer. It specifies why well-designed incentives, pro-

environmental ideologies, and even mobilized public support may fail to stabilize environmental governance once one or more core institutional capacities become structurally unreliable.

Where incentives, norms, and distributive conflict dominate outcomes despite high power concentration, this suggests that structural thresholds have not yet been crossed, not that institutional architecture is irrelevant.

7.6 Environmental Governability as an Architectural Problem of the Anthropocene

The defining paradox of the Anthropocene is the coexistence of unprecedented scientific knowledge and global monitoring capacity with persistently inadequate environmental outcomes. This article has shown that this paradox cannot be resolved by appealing to information deficits, technological scarcity, or political myopia alone. It reflects a deeper problem concerning the institutional feasibility of environmental governance under conditions of concentrated power.

Across global atmospheric governance, Amazon deforestation governance in Brazil, and urban air-quality governance in China, the analysis has shown that informational capacity can expand without generating autonomous correction, enforcement institutions can persist formally while becoming organizationally dependent, and elite incentives can drift away from long-term environmental protection without abrupt ideological change.

A central theoretical implication of the framework is the non-compensability of core governance capacities. Informational abundance cannot substitute for corrective accountability, formal regulatory authority cannot substitute for sustained political orientation, and technological optimization cannot substitute for plural information channels and resilient oversight institutions. Once at least one of these capacities becomes structurally unreliable, environmental governance failure becomes embedded in institutional architecture itself.

The framework also highlights the critical role of institutional hysteresis and lock-in. As informational ecosystems, oversight institutions, and elite selection mechanisms adapt to concentrated power, recovery becomes slow, asymmetric, and politically costly. This creates a dangerous interaction with the threshold dynamics and partial irreversibilities of Earth system processes.

By reframing polycentricity, autonomous oversight, and plural elite recruitment as structural safeguards rather than normative ideals, the article contributes to a more architecture-centered understanding of environmental governance. Polycentricity emerges as a risk-management strategy against the simultaneous erosion of information plurality, enforcement autonomy, and elite diversification.

In the Anthropocene, environmental governance operates under conditions of accelerating biophysical change, deep uncertainty, and political volatility. By reframing environmental governability as an architectural problem of power, information, accountability, and elite selection, this article contributes to a more structurally grounded understanding of why environmental governance so often fails—and under which institutional conditions it might still succeed.

Declaration of generative AI

During the preparation of this work the author used ChatGPT for language revision and structuring. The author reviewed and edited the content and takes full responsibility for the final version.

References

Abbott, K.W., Genschel, P., Snidal, D. and Zangl, B., 2015. International organizations as orchestrators. Cambridge University Press, Cambridge.

Acemoglu, D. and Robinson, J.A., 2012. Why nations fail: The origins of power, prosperity, and poverty. Crown Business, New York.

Aklin, M. and Mildemberger, M., 2020. Prisoners of the wrong dilemma: Why distributive conflict, not collective action, characterizes the politics of climate change. *Global Environmental Politics* 20(4), 4–27.

Andersen, S.O., Sarma, K.M. and Taddonio, K., 2007. Technology transfer for the ozone layer: Lessons for climate change. Earthscan, London.

Andrews, M., Pritchett, L. and Woolcock, M., 2017. Building state capability: Evidence, analysis, action. Oxford University Press, Oxford.

Assunção, J., Gandour, C. and Rocha, R., 2015. Deforestation slowdown in the Brazilian Amazon: Prices or policies? *Environment and Development Economics* 20(6), 697–722.

Bermeo, N., 2016. On democratic backsliding. *Journal of Democracy* 27(1), 5–19.

Biermann, F., Betsill, M.M., Gupta, A., Kanie, N., Lebel, L., Liverman, D. and Young, O.R., 2009. Earth system governance: A research framework. *International Environmental Agreements* 10(4), 277–298.

Biermann, F. and Gupta, A., 2011. Accountability and legitimacy in earth system governance: A research framework. *Ecological Economics* 70(11), 1856–1864.

Biermann, F. and Kim, R.E., 2020. Architectures of earth system governance: Institutional complexity and structural transformation. Cambridge University Press, Cambridge.

Bodansky, D., 2016. The Paris climate change agreement: A new hope? *American Journal of International Law* 110(2), 288–319.

Environmental Effects Assessment Panel (EEAP), 2018. Environmental effects and interactions of stratospheric ozone depletion, UV radiation, and climate change: 2018 Assessment Report. United Nations Environment Programme, Nairobi, Kenya.

Ferrante, L. and Fearnside, P.M., 2019. Brazil's new president and ruralists threaten Amazonia's environment, traditional peoples and the global climate. *Environmental Conservation* 46(4), 261–263.

Fu, S., Gu, Y. and Sheng, Y. (2021). Air Pollution and Manufacturing Firm Productivity: Nationwide Estimates for China. *The Economic Journal* 131(640), 3241–3273.

Gupta, A., Mason, M. and Edwards, G., 2014. Technology, transparency, and accountability. In: Gupta, A. and Mason, M. (Eds.), *Transparency in global environmental governance*. MIT Press, Cambridge, MA, pp. 1–18.

Hooghe, L. and Marks, G., 2003. Unraveling the central state, but how? Types of multi-level governance. *American Political Science Review* 97(2), 233–243.

INPE, 2023. PRODES and DETER deforestation monitoring data and technical reports 2023. Instituto Nacional de Pesquisas Espaciais, Brasília.

IPCC, 2023. Sixth Assessment Report (AR6): Complete Assessment Cycle. Intergovernmental Panel on Climate Change, Geneva.

Jacobs, A.M., 2016. Policy making for the long term in advanced democracies. *Annual Review of Political Science* 19, 433–454.

Jänicke, M. and Jörgens, H., 2006. New approaches to environmental governance. In: Mol, A., Sonnenfeld, D.A. and Spaargaren (Eds.), *The Ecological Modernisation Reader*. Routledge, London, chapter 10.

Jasanoff, S., 2004. *States of knowledge: The co-production of science and social order*. Routledge, London.

Jordan, A., Huitema, D., Schoenefeld, J., van Asselt, H. and Forster, J., 2018. Governing climate change polycentrically: Setting the scene. In: Jordan, A. et al. (Eds.), *Governing climate change polycentrically*. Cambridge University Press, Cambridge, pp. 3–25.

Keohane, R.O. and Victor, D.G., 2011. The regime complex for climate change. *Perspectives on Politics* 9(1), 7–23.

Kostka, G. and Zhang, C., 2018. Tightening the grip: Environmental governance under Xi Jinping. *Environmental Politics* 27(5), 769–781.

Levitsky, S. and Ziblatt, D., 2018. *How democracies die*. Crown, New York.

Li, W. and Michalak, K., 2012. Environmental compliance and enforcement in China. In: P. R. Young, ed. *Governance, Risk, and Compliance Handbook*. Hoboken, NJ: Wiley, pp.379-390.

Michels, R., 1915. *Political parties: A sociological study of the oligarchical tendencies of modern democracy*. Free Press, New York.

Mitchell, R.B., 2008. Evaluating the performance of environmental institutions. In: Young, O.R. et al. (Eds.), *Institutions and environmental change*. MIT Press, Cambridge, MA, pp. 79–114.

Mol, A.P.J., 2011. *Environmental reform in the information age: The contours of informational governance*. Cambridge University Press, Cambridge.

Mosca, G., 1939. *The ruling class*. McGraw-Hill, New York.

Nepstad, D., McGrath, D., Stickler, C., Alencar, A., Azevedo, A., Swette, B. et al., 2014. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* 344(6188), 1118–1123.

Newell, P., 2012. *Globalization and the environment: Capitalism, ecology and power*. Polity Press, Cambridge.

Newell, P. and Paterson, M., 2010. *Climate capitalism: Global warming and the transformation of the global economy*. Cambridge University Press, Cambridge.

Ostrom, E., 2010. Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change* 20(4), 550–557.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E. et al., 2009. A safe operating space for humanity. *Nature* 461, 472–475.

Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D. et al., 2018. Trajectories of the Earth system in the Anthropocene. *Proceedings of the National Academy of Sciences* 115(33), 8252–8259.

Stevenson, H. and Dryzek, J.S., 2014. *Democratizing global climate governance*. Cambridge University Press, Cambridge.

Turnhout, E., Metzger, T., Wyborn, C., Klenk, N. and Louder, E., 2019. The politics of co-production: Participation, power, and transformation. *Current Opinion in Environmental Sustainability* 42, 15–21.

UNEP, 2023. *Emissions gap report 2023*. United Nations Environment Programme, Nairobi.

Victor, D. G., Geels, F. W., & Sharpe, S. (2019). *Accelerating the low carbon transition: A report of the Energy Transitions Commission*. Energy Transitions Commission.

Young, O.R., 2017. *Governing complex systems: Social capital for the Anthropocene*. MIT Press, Cambridge, MA.