Advanced Review

Mitigation and adaptation in polycentric systems: sources of power in the pursuit of collective goals

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Polycentric governance involves multiple actors at multiple scales beyond the state. The potential of polycentric governance for promoting both climate mitigation and adaptation is well established. Yet, dominant conceptualizations of polycentric governance pay scant attention to how power dynamics affect the structure and the outcomes of climate action. We review emerging evidence on power within polycentric and distributed governance across the climate, forestry, marine, coastal, urban, and water sectors, and relate them to established positions on power within research on federalism, decentralization, international relations, and networked governance. We develop a typology of design, pragmatic, and framing power that focuses on how and in whose interests power is mobilized to achieve outcomes. We propose that the conceptual model helps to explain power dynamics across different sectors and across both climate change mitigation and adaptation. Significant research challenges arising from the analysis include the measurement and monitoring of the outcomes of power asymmetries over time.

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INTRODUCTION

Deliberate strategies to address environmental change are critical for achieving long-term environmental sustainability. In climate change policy, strategies are needed to address episodic and extreme events such as wildfires, droughts, floods, and heatwaves, as well as the long-term interactions between climatic and socioenvironmental processes. For the past few decades, a number of models to govern and manage these issues have emerged, ranging from traditional forms of governance (e.g., markets, communities, and governments) to hybrid forms of governance (e.g., public–private partnerships, concessionary mechanisms, and community-based interventions). New multilevel approaches seek to

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avoid the pitfalls and limitations of earlier approaches and to advance governance toward desirable norms such as local participation, representation, equity, legitimacy, accountability, innovation, and efficiency.[1,2] More recently, polycentric governance has increasingly gained traction among both scholars and policymakers.[3]

Polycentrism is a model of governance that actively steers local, regional, national, and international actors and instigates learning from experience across multiple actors, levels of decision-making, and temporal scales.[3,4] In its most prevalent conceptualization, it is a nonhierarchical set of interactions between public and private actors operating at multiple levels (e.g., supranational, national, and subnational) without a predominant central authority.[5] A polycentric system is made up of many autonomous units that are formally independent of one another but which choose to act in ways that take account of others through self-organized processes of cooperation and conflict resolution.[6,7]

Yet recent critiques have highlighted several inherent contradictions and limitations of polycentrism. Jordan et al.[8] challenge the prevailing enthusiasm about polycentric governance in dealing with climate change, pointing out untested assumptions about diffusion and performance of novel governance approaches. Other research reveals the limitations of polycentric governance for arresting the world's alarming deforestation rates through programs such as Reducing Emissions from Deforestation and Forest Degradation (REDD+).[9] Evidence from polycentric experiments in urban planning for climate change has underscored the challenges in engaging with the economic and political dimensions of cities.[10,11]. Some strands have alluded to the role that power may play in undermining the advantages of polycentrism over other forms of governance.[12,13]

At the heart of conceptualizations of polycentric governance is the focus on the emergence of decentralized yet networked arrangements that are connected through processes of cooperative learning. However, by downplaying the hierarchical or multilevel structures within which polycentrism is embedded, these frameworks often ignore not only different types of power at play but also how their distribution may affect both governance processes and environmental outcomes. Empirical research shows that many systems that are described as polycentric are critically shaped by power, both positively and negatively. For example, forest policy under the REDD+ program, which is generally regarded as polycentric, is actually embedded within established hierarchies of centralized control and state ownership of forest land.[9] Similarly, empirical research on REDD+ in Indonesia shows that powerful organizations can and do shape governance structures to their own interests.[14] Moreover, the conceptualization of polycentrism as self-organizing and nonhierarchical can be problematic when the state is in effect a partner in most governance schemes.[2,15] Indeed, the literature on decentralization and community-based management of natural resources often exposes the inherent contradictions of purposefully 'choosing' to self-organize, and shows that the changing relationships of power at all levels are critical to understanding outcomes.[16,17] Finally, some studies suggest that multiscale governance of environmental risks and adaptation is better conceptualized as both decentralized networks of cooperative learning *and* as expressions of power-laden social relations.[18]

Polycentric governance is often equated with state decentralization of authority in order to keep central power in check.[19,20] By limiting central power, polycentrism is purported to avoid the failures of state-centered governance while simultaneously empowering different actors and organizations to work together across and at the appropriate scale to solve critical environmental problems. Yet, it appears that in the pursuit of minimal active management by the state, polycentrism has been inadvertently rendered power-free. We believe that in order for polycentrism to meet its promise, its analysis and practice need to be much more explicit about power in order to both reveal and address power imbalances and achieve better outcomes.

In this article, we explore these issues, focusing particularly on the role of power in polycentric governance. We first show how existing work on polycentric governance has generated significant new understanding but how it still needs to incorporate the different ways of accounting for power. We then employ insights from a number of recent studies across the climate, forestry, marine, coastal, urban, and water sectors, and relate them to the findings that have emerged from much older strands of work on federalism, decentralization, international relations, and networked governance. In particular, we explore the diverse strands of literature in order to identify different forms of power and how they may affect processes and outcomes of polycentric governance. We show the potential for deeper collaboration across a number of disciplines and multiple conceptualizations of power in order to produce a more comprehensive analysis of polycentric governance. In the concluding section, we outline the most significant research gaps identified from our analysis.

WHAT IS POLYCENTRIC GOVERNANCE?

At first glance, it is possible that any and every arrangement with multiple actors governing across different scales could claim to be polycentric since the *degree* of *coordination* and level of *purposeful design* might lie in the eye of the beholder. For example, the European Union has often been understood as both a multilevel system and a polycentric system. Hence, establishing some core examples of what represents ideal types of polycentric governance, and contrasting them with examples that clearly are not, can be difficult.

Polycentricity was initially defined as the antithesis of *monocentric* systems: those controlled by a single unitary state power (e.g., a comprehensive governmental authority).[6] By contrast, an ideal-type *polycentric* system comprises multiple governing authorities at different scales who do not stand in hierarchical relationship to each other but function nonetheless as a coordinated system.[3,5] These individual authorities take account of others through processes of cooperation, conflict resolution, self-organization, and mutual adjustment. Polycentric systems are also not to be confused with ideal-type *multilevel* systems, which involve a nested structure with a central predominant government authority whose decision-making is based on constituent interests (e.g., lower level authorities).[21] In multilevel systems, tasks and decisions are allocated according to a classic *federal* structure or *decentralized* unitary structure, where different actors at different scales are responsible for different policy problems. Polycentric systems share more characteristics with *networked* governance systems, which are also characterized by a nonhierarchical yet interactive constellation of public and private actors at multiple levels (e.g., supranational, national, and subnational) without a central predominant authority.[10,22] It is also worth noting here that *fragmented* systems can also exhibit dense networks,[23] but they lack self-organization and mutual adjustment which are the defining features of polycentric systems (Table 1). Finally, it should be acknowledged that all of these categories are ideal types that are not exclusive of each other and do not necessary function in the ideal way in practice.

Polanyi first introduced the concept of polycentric governance in his classic 1951 text, *The Logic of Liberty*.[24] Vincent Ostrom developed the concept further in his 1961 study of metropolitan governance.[6] Over the last decade, the significant influence of Elinor Ostrom and colleagues' work on nonmonocentric collective-action solutions for the provision of environmental goods and services has seen the polycentric model gain important traction in climate, resilience, and adaptation studies.[7,25–27] This strand of literature includes several important demonstrations of how small-scale or single resource-use systems have scaled up over time in response to relatively simple common use rules nested within polycentric systems.

TABLE 1 | Defining Characteristics of Polycentric Governance Systems

- Many autonomous units formally independent of one another
- Multiple overlapping scales
- Units choose to act in ways that take account of others (though mutual adjustment)
- Self-organized processes of cooperation and conflict resolution
- System-like behavior

These studies highlight that multiple centers of decision-making can and do interact at many different scales. However, due to a lack of empirical data, measurement challenges, and problems of attribution, early work on polycentric environmental governance often took a normative or descriptive case-study approach to understanding polycentric systems.[7,28] The results remained largely descriptive (complexity as the new reality) or normative (complexity should be solved through bottom-up adaptation and participation across institutional contexts).[29]

More recently, polycentricity in environmental governance has been conceptualized as ranging from weak coordination to strong polycentric order (Figure 1). Monocentricity and polycentricity are extremes, with many systems existing on a continuum between them.[7] Strong polycentric order is associated with a high dispersion of power. The degree of order is explained by concurrence of social capital, leadership, communication dynamics, negotiation of trade-offs, degree of formalization, and structural patterns of networks such as scale bridging and coordination.[33,34]

However, while this approach provides useful insights into analysis of internal social structures and processes of polycentric governance, the empirical literature is only beginning to address the strength and authority of macrolevel political institutions.[35] Huitema et al.[28] attribute this gap to the normative and pragmatic underpinning of polycentric governance which judges that local self-government is best. The principle of *subsidiarity*—that government functions best at the lowest feasible level—is often invoked in order to limit the power and responsibility of higher

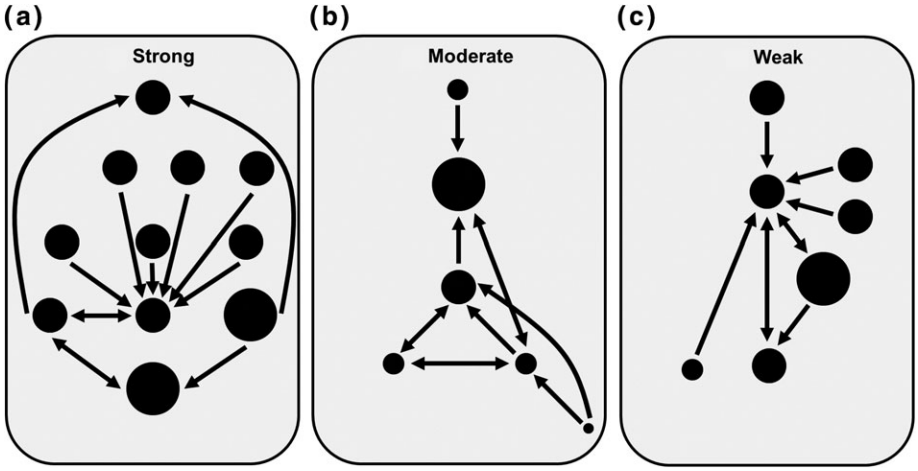

FIGURE 1 | Different polycentric structures in three climate-affected regions. (a) A strong and highly decentralized polycentric system in coastal California (USA), for example, where the open coast and San Francisco Bay area are regulated by entirely different state laws and governing bodies. The California State Government has historically played an equal or greater agenda-setting role in climate mitigation and adaptation than the national government; however it is restricted by the significant administrative powers and responsibilities held by the 74 coastal cities and counties.[30] (b) The climate-affected Murray–Darling Basin (Australia) covers four states and a federal territory within a centralizing federal system that is signatory to a number of international conventions.[31] This is regarded as a moderate form of polycentrism which is becoming less polycentric as it centralizes. (c) The climate-exposed North Sea coast of Germany is cooperatively managed by five states and the national government, which is also a member of the European Union.[32] This example is regarded as a nascent form of polycentrism, which is still subject to issues of fragmentation.

levels in favor of promoting strong, independent roles at local and regional levels.[34,36] Yet, central to the claims made for polycentricity are multiscale issues of power and responsibility. Indeed, multiscale power dynamics can move polycentric regimes between decentralized, recentralized, and fragmented states over time, with implications for both the structure of the system and its ability to achieve outcomes.[37] Understanding such polycentric power dynamics, however, is neither easy nor straightforward. As the study of polycentricity matures, there is a pressing need for a more analytic interrogation of not only how power is distributed across polycentric systems but also how power is mobilized to achieve effective systems and how it affects policy and management design.

It is not surprising, therefore, that a robust and active debate has begun to emerge concerning the power dynamics of polycentric environmental governance, spanning the international climate, urban, forestry, coastal, and marine sectors. This debate is provocative because it is beginning to question the efficacy of polycentric governance in a field that has long tended to be overly exuberant about the promise of polycentrism. Emerging critiques highlight how the focus on soft interventions (nudging behavior, devolution of responsibilities, fiscal incentives) in polycentric governance has precluded more interventionist approaches and failed to deal with issues such as power imbalances and social and ecological justice. However, we suggest that the task challenging scholars of 'the new critical polycentrism'[7–9,38] is to develop a framework to identify and understand power and its implications. As a first step, next, we revisit why polycentric governance is important for adaptation, resilience, and transformation.

WHY POLYCENTRIC GOVERNANCE IS IMPORTANT FOR CLIMATE MITIGATION AND ADAPTATION

Environmental variability and change are characterized by cross-scale (spatial and temporal) linkages and feedbacks that generate nonlinear dynamics and uncertainty. These linkages and feedbacks cross boundaries, cause complex social–ecological interactions, and generate problems of institutional fit (Table 2). In such situations, the transformative potential of polycentric governance has been persuasively argued and widely advocated.[3,4] Figure 2, for example, shows that there has been exponential growth of scientific interest in polycentric governance since Elinor Ostrom spearheaded an intellectual campaign exploring the potential of polycentric governance to address global climate change.

There are many core arguments regarding the importance of polycentric systems. First, a polycentric

TABLE 2 | Examples of Dilemmas Posed by the Nature of Climate Variability and Change[39–43]

- Temporal scale—trade-offs exist between protection of what exists now (infrastructure, economies, and values) and long-term adaptation. This temporal dimension leads to moral hazard—short-term actions and interventions that compromise, limit, or trade-off actions in the future (e.g., maladaptation)
- Spatial scale—adaptation actions in one place may have negative impacts elsewhere—either immediately downstream or in more remote places (e.g., teleconnections)
- Transboundary issues—parts of the environment have shared jurisdiction or where natural resources cross boundaries—such as the global atmosphere, oceans, various water bodies, and migratory species (e.g., fish stocks)
- Social–ecological interactions—environmental variability inevitably interacts with complex social dynamics, such as place, identity, and human mobility
- Nonlinear dynamics—social–ecological systems exhibit nonlinear or threshold responses to changes in climate variability
- Cross-scale feedbacks—complex interactions at different spatial or temporal scales generate thresholds and alternate stable states
- Institutional fit—the scale of governance must be capable of responding to the scale of the policy problem

approach is capable of considering multiple environmental, social, or economic conditions. This flexibility allows for more democratic representation and legitimization of decisions. Second, because the potential pathways to solutions of complex problems are ill-defined, polycentric systems can provide an environment in which different actors can experiment with their preferred strategy of adapting to environmental variability and change. This capacity is also beneficial from a risk management perspective, because a 'one-size-fits all' approach may fail and this failure may well have critical adverse implications.[28,44] Third, because the effects of environmental variability and change are location-specific, a polycentric approach permits tailoring of adaptation activities to suit local-regional circumstances and community preferences.[28,45] Fourth, polycentric systems allow for specialization and the division of tasks between central, regional, and local levels, thus improving the efficiency of adaptation activities by matching the governance level to the geographic scale of the problem.[33] Fifth, many scholars believe polycentric systems to be flexible in their ability to configure and reconfigure alliances rapidly in order to achieve specific goals, which in turn makes them inherently adaptive. Sixth, polycentric systems are regarded as being more robust to external stresses and shocks because they can recover more quickly due to their diversity. Their high degree of overlap and redundancy also makes them less vulnerable: if one element fails, others may take over their functions (although some scholars have argued that redundancy may counteract nimbleness and flexibility).[7,46,47] Finally, in many policy-making scenarios, the multiple causal factors and symptoms involved, the high levels of uncertainty about the set of solutions, and the lack of definitive answer as to who is responsible for the

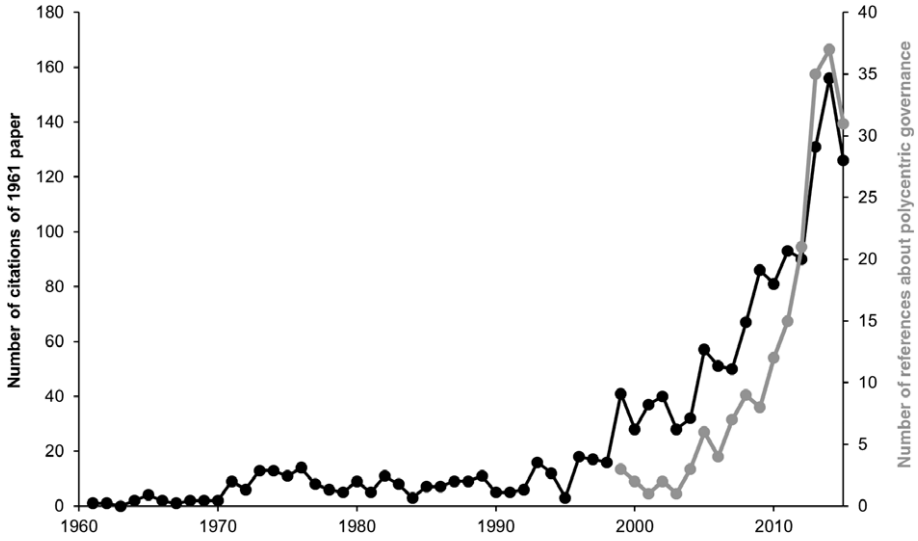

FIGURE 2 | Exponential growth of scientific interest in polycentric governance. Citations to Vincent Ostrom's seminal article on polycentric governance[7] (black) and published articles on polycentric governance (gray).

solution mean that a more monocentric approach is impossible, making polycentricity, in this sense, 'a fact of life.'[28,48,49]

Polycentric governance (along with multilevel, networked, and fragmented governance) has also raised well-documented concerns. First, if different levels of governance opt for conflicting policies, the result can be leakages, meaningless certification, policy incoherence, unnecessary duplication of efforts, counterproductive actions, and/or complete gridlock.[3,4,28,50] Second, competition between levels and/or responsibilities spilling over from one level into another can lead to suboptimal standards for mitigation and adaptation. For example, when neighboring communities handle land-use planning in risk-prone areas loosely in order to attract short-term-oriented investors, the environmental effects of these activities may *spill over* to neighboring regions.[51] Third, in polycentric systems, the costs in time and money of collective action (consultation, reaching agreement, and enforcing such agreements) are high due to the 'complexity of spatial patterning, multiple functional overlays, partial polity formation, and variable system coupling.'[5] This cost is especially high if the basic units in the polycentric system are very small, requiring the involvement of a larger number of stakeholders and the need for more information.[25] Fourth, in a polycentric structure where responsibilities are very dispersed, new collaborative processes and organizations such as intergovernmental committees or specialized agencies are often set up to steer the system.[52,53] Many of these agencies may prioritize goal achievement over democratic procedure, circumventing the 'troublesome' and 'time-consuming' procedures designed to ensure accountability and transparency at lower levels.[5,19,28,54] Fifth, polycentric systems are believed to suffer from a tendency for inertia and paralysis, especially when efforts to preserve the system's own existence or permanence overtake attempts at implementation.[55] Sixth, although polycentric systems may be more robust to external stresses and shocks due to their diversity, emerging research shows that polycentric systems are very vulnerable to internal structural and procedural issues, broader economic factors, and shifts in political sentiment.[8,37] Furthermore, because polycentric systems appear to be a self-organizing 'fact of life,' the opportunities to design and control such systems are inherently limited.[26,33]

However, despite progress in understanding polycentric governance, the lack of comparative and meta-analysis of the growing library of case studies suggests that there is much work to be done in resolving potential contradictions and addressing many contemporary assumptions. In particular, while polycentric governance involves both a configuration of institutions and power, the structural patterns of networked institutions in polycentric systems have received far more attention than the configuration of power relations across those structures. This omission is problematic in that it not only obscures venues for legitimacy and efficiency in decision-making but also reproduces unchallenged assumptions about the appropriate level and organization of institutional responses to complex policy problems.[46] Structural analyses of networked institutions have unintentionally downplayed the important role of the nation state, the powerful private actor, the international authority, and the organized bureaucracy, and left a noticeable gap in the literature on the real potential for addressing environmental change within polycentric systems.[8,56,57] This bias away from the nation-state and other powerful actors also pervades the broader governance literature (see Table 3). It deserves specific attention because overlooking the mobilization of power can render mitigation and adaptation within a polycentric system difficult to understand and to implement, and may risk reinforcing opposition and hostility toward large-scale action by particular actors such as nation states.[51,58]

TABLE 3 | Understanding the Distribution of Power in Contemporary Governance Studies

Key Fields	Key Concepts	Key Scholars	Distribution of Power
International relations	Multilateralism, global governance	Keohane, Nye, Rosenau, Rosendal	Upward from nation state
Federalism and EU studies	Multilevel governance	Scharpf, Borzel, Hooghe and Marks, Bache and Flinders	Downward from nation state
Political science	Decentralization	Crook and Manor, Tendler	Downward from nation state
Public policy and administration	Network governance, fragmented governance	Peters and Pierre, Rhodes, Bell and Hindmoor, Jessop	Sideways from nation state
Institutional economics	Polycentric governance	V. Ostrom, E. Ostrom, McGinnis	Upward, downward, and sideways from nation state

Understanding adaptation in polycentric systems is easier if we understand the system not only as a set of institutions, agencies, and actors but also as an expression of power-laden social relations that affect both adaptive capacities and policy implementation.[18,57] Indeed, all governance involves the redistribution of power. Effective governance can thus be supported or resisted, depending on the normative agenda of the actors involved and whether that agenda is advanced by polycentrism. But what enables these different actors to wield power, and to prevent or encourage the competitive (and potentially maladaptive) behavior of other actors?

LOCATING POWER AND AUTHORITY IN POLYCENTRIC CLIMATE GOVERNANCE

While there are many theories of power they all converge in highlighting that power is unevenly distributed and socially contested, with consequences for the creation and distribution of resources, opportunities and well-being.[59–62] Theories diverge in their emphasis on individual and collective dimensions, on how power is active and observable or alternatively hidden and slippery, and on how the consequences of the exercise of power are deliberate or largely unintended.[63] Many social science theories and analyses of environmental governance illuminate divergent aspects of power, distinguishing between, for example, institutional, social, reputational, framing, political, legal, rational, relational, and practical aspects, as well as between power and agency.[14,64–69] These categories are not mutually exclusive and may be fluid. They are often developed in a pragmatic fashion to help identify the aspects of power that affect, distort, and often undermine the fundamental goals of governance. Yet, there is surprisingly little work drawing these aspects together into a comprehensive typology (but see Ref 61). Table 4 presents such a framework: it identifies three comprehensive categories of power that we argue most frequently shape governance. Our categorization focuses on how power varies according to the authority to make decisions and distribute resources (power by design), to administer and implement rules (pragmatic power), and to interpret knowledge and set norms (framing power). For each of these categories, power is a relational concept because it only emerges through interactions and cannot always be retrieved by looking solely at certain individual interactions or exchanges. Rather, it is precisely the iterative nature of these interactions that leads to the establishment of certain reputations, network structures, institutional arrangements, or principles. In this sense, power has an emergent property and actors behave in a certain way not only because they are powerful but also because they want to become more powerful or stay as powerful as they have been. Similarly, the balance of power can shift, sometimes quickly and dramatically, from actor to actor or organization to organization. In the following, we discuss the different types of power, the causes and consequences of asymmetric power, and the implications of unveiling such asymmetries. Because power is not easy to observe and measure[70] we also provide examples of typical methods of measurement.

Power by Design

A governance regime is often defined by how its decision-making powers are distributed among actors at different levels. These powers can be constitutionally guaranteed (e.g., in a federation) and distributed jurisdictionally (e.g., devolution of decision-making powers to lower levels of actors). The concentration of power can be dispersed by actions such as establishing regional organizations for environmental management or the creation of semi-autonomous agencies, commissions, or statutory authorities headed by appointees of the decision-making authority. A redistribution of power is thus the outcome of such vertical deconcentration or delegation.

In polycentric governance, high-level actors, trans-national commissions, governments, and multilateral organizations usually have some but limited decision-making power. Decision-making power in this context refers not only to the ability to legislate and allocate resources, but also to undertake structural adjustment, redesign markets, and regulate externalities.[71] More often than not, states play a dominant role by retaining ultimate control over critical environmental resources such as water and forests. Extensive research has shown how states tend to retain power even where they apparently devolve power to lower levels of decision making, and in their efforts to seek to correct and limit elite capture, and prevent the overuse and illegal use of resources.[65,72]

One of the goals of polycentric regimes is precisely to redistribute decision-making power to other actors and levels of government,[67] yet such devolution is rare in practice.[73,74] State-centered governance regimes routinely exercise power by design in apparently polycentric systems. Sovacool,[38] for example, shows how a key element in successful polycentric approaches to energy and climate governance in Denmark, Brazil, Bangladesh, and China was 'a central

TABLE 4 | Sources of Power and Authority in Governance Systems

	Power by Design	Pragmatic Power	Framing Power
Definition	Formal authority with capacity to make rules, allocate resources, undertake structural adjustment, redesign markets and administrative structures, to tax, and regulate resource use and externalities. Includes legal power, political power, administrative power, and institutional power	Primarily informal authority with capacity to interpret, certify, and monitor rules, influence other actors, control information, to 'govern by doing' through the day-to-day implementation of governance mechanisms. Includes practical power, social power, reputational power, and mediating power	Often invisible authority with capacity to develop codified rules and knowledge, to frame problems, construct issues and set norms. Includes discursive power and epistemic power
Examples of typical methods of measurement	Documentary analysis of relevant institutional arrangements, receipt and distribution of fiscal resources; employee and budget numbers in organizational documents (qualitative and quantitative)	Qualitative survey of legal interpretation and bureaucratic perception; in-depth qualitative studies of practitioners, combining significant periods of observation with multiple interviews	Discourse analysis of key texts; process tracing of paradigm changes; qualitative assessment of disciplinary expertise; ethnographies; analysis of qualifications and professional standing of personnel

state willing to levy taxes, implement regulations, and invest in innovation—purposefully manipulating markets to change technologies and behaviours' (p. 3842). Similarly, in the case of the Australian Murray–Darling River Basin, which spans across several states, the national government has drawn upon its power to enforce treaties (the international RAMSAR convention on wetlands) in order to impose a new national *law*, and thereby override political maneuvering by lower levels of government and other stakeholders.[31] The fiscal dependence of the states on the national government has provided the national government with considerable political leverage in the Basin[75] and consequently decision-making power has become increasingly centralized in order to enhance the Basin's resilience to climate change.

Decision-making power within other polycentric regimes assumes different forms and reach. In the state of California, while decision-making power for coastal climate adaptation is the responsibility of the state, the national USA Coastal Zone Management Act 1972 rewards coastal states for developing and implementing state-level coastal regulatory programs.[30] However, federal agencies must conduct their activities (including federal development projects, permits, and licenses, and assistance to state and local governments) in a manner consistent with the state program.[30] As a result, decision-making power for adaptation on the California coast is far more decentralized than in many other cases, with more powers attached to lower levels.[76] Likewise, the central German government has fostered a soft national *strategy* relevant to adaptation on the German North Sea coast that has been developed in a consultative mode with the states (the Lander), the European Union, and other adjacent European countries. The Lander shares responsibility with the national government for decision-making *and* delivery in this arena but is reluctant to take over new and additional tasks without sufficient compensation for associated expenditures.[51,77,78] The federal government provides up to 70% of the funding of capital costs for coastal protection infrastructure and the states contribute the remaining 30%.

In effect, fiscal power, administrative power, and the power to make meaningful decisions continue to comprise the most visible manifestation of power in polycentric regimes. Indicators such as the size and hierarchical arrangement of organizational structures and the receipt and distribution of organizational resources at different levels can reveal administrative and fiscal power. Similarly, the distribution of decision-making power can be revealed through analysis of relevant institutional arrangements (Table 4).

Pragmatic Power

Pragmatic power refers to the exercise of functional powers by different actors through their influence on day-to-day decisions. In contrast to the formal and more visible nature of power by design, pragmatic power resides in how organizations and actors

influence both the decision-making context and implementation process. There is substantial evidence on how bottom-up policy is implemented: analysis of network governance, for example, shows the informal yet legitimate ways in which street-level bureaucrats and noncentralized organizations exert power through the implementation of formal rules and norms set by others.[79,80] Power materializes, for example, in the interpretation of guidelines, the undertaking of performance evaluation, the solving of problems, and the actual implementation of governance mechanisms. High- and local-level bureaucracies and nonstate actors such as corporations and activist groups are in effect pragmatic power-brokers.[53,65,81]

Shadow and dormant networks of pragmatic power-brokers can mobilize pragmatic power very rapidly when necessary.[82] Indeed, one key element of polycentric governance systems is that in order to function properly, the various governance sites and levels need to be connected. For instance, from the perspective of learning (the spreading of 'best practices' from elsewhere) and mutual adjustment, local sites need to be connected with each other and the overall experiences of various localities needs to assessed at a higher level. In addition, some level of vision building at the higher-level needs to guide local experimentation. Networks of leaders, entrepreneurs and/or other 'elite agents' mobilize their unique abilities and qualities (e.g., charisma) and the place they occupy in networks in order to pragmatically determine choices.[35,83]

Examples of the exercise of pragmatic power within polycentric systems include the California Coastal Commission, mandated by the California Coastal Act. While it exercises high decision-making power over adaptation in the state's coastal zone, pragmatic power over local planning decisions actually resides at the city and county level under the rubric of state environmental planning law.[84] Similarly, in Brazil's decentralized water management, well-connected members of river basin committees (constituted of representative users, state officials, and others) exert *de facto* pragmatic power in governance of climate impacts by circumventing membership rules established to prevent long-term accumulation of power. Since membership representing any sector is limited to two years, well-connected actors are able to extend their influence by negotiating representation with a different sector every time their membership expires. On the one hand, these actors have been able to exert considerable power over decisions at the expense of broader representation, whereas on the other hand, they have played pivotal roles in guarding institutional memory and continuity.[57,85] In Indonesia, powerful organizations use their reputational power to influence decisions in the implementation of climate mitigation schemes such as REDD+, especially by controlling the exchange of information across levels, which is usually out of reach for other organizations because of the high transaction costs it involves.[14]

In seeking to understand and measure pragmatic power, it is possible to study legal interpretation and bureaucratic perception of who has the power to influence the decision-making context and then interpret, certify, and monitor policy priorities, adaptation frameworks, and compliance.[65,86,87] This kind of information can be elicited through documentary or archival review (e.g., of organizational annual reports), key informant interviews, and surveys of participants in polycentric governance processes (e.g., to gauge access to formal political power, and patronage relationships involving key agencies and politicians) (Table 4).

Framing Power

Framing power is realized when individuals, institutions, and organizations have the ability to frame problems and set norms.[88] In polycentric systems, this kind of power can skew authority and set agendas, especially if technical knowledge is uncontested and perceived as superior to other forms of knowledge.[86,89] Framing power-brokers produce codified rules over areas of knowledge (traditionally in engineering, science, economics, medicine, and law) and are typically evident by the existence of a large, well-funded, and well-educated constituency with concrete discernible interests, broader political support, and the public good plans and initiatives that emanate from this support.[90] In the environmental domain, engineering and forestry experts in the US Corps of Engineers and the US Forest Service, for example, are classic examples of significant actors wielding great framing power.[86]

In California in the 1980s, state agencies that were dominated by legal experts interpreted separate provisions of the California Coastal Act to allow shoreline defense for existing structures in imminent danger from coastal erosion. As a result, seawalls became the most common form of coastal defense (and approximately 12% of the California coastline was engineered) while other states such as Oregon, Maine, and North Carolina have partial or full seawall prohibitions in place. While institutional and attitudinal barriers to climate adaptation still exist today at the local and state level, the California Ocean

Protection Council, the Coastal Commission, and the California State Coastal Conservancy are working to reframe the problem and set new norms, this time focusing on soft approaches to coastal defenses.[91,92]

In Brazil's decentralized water management system, technocrats (técnicos) frequently mobilize 'apolitical' scientific information to increase regional decision-making capacity and policy implementation. By controlling the production and access to knowledge (e.g., climate forecasts) these technocrats are able to insulate decisions from river basin committee members and drive different agendas. For example, in dry north-eastern Brazil, técnicos have been able to prioritize a highly risk-averse agenda for water management that favors ecosystem health, whereas in the relatively water-rich south-east, hydropower companies dominate decision-making at the expense of other water users.[89] Here, environmental outcomes appear to be predicated by the value systems and interests of these técnicos and their organizations rather than by established governance goals.

Similarly, until the 1990s, the framing of water variability in the Murray–Darling Basin in Australia was exerted by government agencies dominated by engineering experts who were largely concerned with the construction of public works to manage flows and store water for irrigation purposes. More recently, it has become clear that the expansion of irrigation has long exceeded sustainable limits.[93] The architects of the subsequent Draft Basin Plan (the ministerial council) successfully shifted the parameters of the debate from a sole focus on the socioeconomic viability of irrigated agriculture communities to a new focus that included environmental sustainability in a changing climate.[94]

In the international polycentric system for water governance,[95,96] much of the global debate on managing the effects of climate change takes place in fora such as the World Bank, where countries rather than individual farmers are represented, and where some countries are much more capable of steering the debate than others because they have more resources for representation at that forum.[97] Subsequently, ideas emanating from wealthier countries are adopted, and the policies of international organizations reflect the priorities of those countries. This dominance has consequences. For example, where the help of international organizations is sought (e.g., in the form of a loan for the development of critical infrastructure), specific policies must be accepted as a condition for financial aid and reapplied in situations which are inappropriate.[98]

Strong framing power can emerge from a persuasive base of disciplinary expertise in a highly regarded profession, including at the leadership level.[86] Framing power can be elicited through records of organizational workforce (e.g., annual reports) which usually indicate not only the total number of personnel but also the professional base of that personnel in terms of qualifications and disciplinary mix. The distribution of framing power can also be analyzed in terms of the existence of concrete groups (e.g., nonprofit organizations and intergovernmental groups) and their involvement in setting the agenda for public-good plans and initiatives. This distribution can be understood through documentary review (e.g., discourse analysis of key texts and process tracing of paradigm changes), qualitative assessment of disciplinary expertise, ethnographies, and participant observation, and quantitative analysis of number of personnel with advanced or professional qualifications (Table 4).

Causes and Consequences of Asymmetric Power Distribution in Polycentric Climate Governance

The different types of power identified above are neither static, nor are they evenly distributed. Indeed, scholars of power have long questioned ideals about stable and balanced power, favoring more fluid and asymmetric understanding. Empirical research show that asymmetries in the distribution of power emanate from different sources, including disparities in wealth, education, rights, representation, information access and control, patronage, and military might. These asymmetries are further obscured by recent trends in the decentralization, technocratization, marketization, and privatization of environmental governance, which have increased the reach of private and NGO power, but without the traditional accountability and legitimacy checks of the democratic state.[99,100] And, despite the distributed power ideal, polycentric governance of climate, rather than being immune to these asymmetries, is as vulnerable to them as other forms of governance. For example, recent research has shown how the asymmetric qualities of power, when left unchecked, can affect the outcomes of polycentric governance. Unchecked power imbalances in polycentric governance of REDD+ and the Global Environment Facility's Least Developed Countries Fund have skewed stakeholder representation and risk, reinforcing preexisting elites while further marginalizing the vulnerable.[14,38] Unaccountable private and NGO influence, combined with general retreat of state responsibility for public goods and services, can have serious implications for

both climate mitigation and adaption, both in terms of capacities and policy implementation.[37,101]

Methods for Unveiling the Dimensions of Power

We have argued above that while polycentric climate governance clearly involves both a configuration of institutions and power, the structural patterns of networked institutions in polycentric systems have received far more attention than the configuration of asymmetric power relations across those structures. This emphasis on network structure has led to an overconcentration on power by design. Yet, understanding adaptation and mitigation in polycentric systems is easier if we understand the system not only as a decentralized networks of cooperative learning across institutions, agencies, and actors, but also as an expression of power-laden social relations.[18] This understanding illuminates other less visible forms of power such as pragmatic power and framing power. We suggest here that these less visible forms may be the more dominant modes through which collective goals in polycentric systems are sought and sometimes achieved. Unveiling such power dynamics is not easy.[70] Power dynamics will always vary on a case-by-case basis and may involve tangible (time, money, and financial) and intangible (trust and legitimacy) transaction costs. However, if we want to improve the design and outcomes of polycentric governance in any meaningful way, we need to identify and understand the (negative and positive) roles power can play. Here, we have provided examples of typical methods of observation and measurement that are applicable across cases.

Attention to these different types of power offers new promise for governing complex environmental problems, in a number of ways. First, by revealing the different types of power, governance actors can assess power dynamics and how asymmetries can increase the risks for corruption and other abuses of power (such as closed-door deals, conflicts of interest, illegal finance, and patchy law enforcement). Here, knowledge can empower actors and help them to influence others.[100] Such actions can include exposing asymmetric power dynamics through new information, advocating changes to societal norms or government and industry policies or rules, mobilizing new interest groups and coalitions, and generating other forms of countervailing power.[48,102,103] For example, in the Brazilian water management example, técnicos have been able to use climate information as leverage to curb both economic and political power within river basin committees.[89] Fung[104] also describes, for example, the generation of a 'civic immune system' whereby an ecology of transparency, accountability, and monitoring mechanisms and associations can monitor and disclose information to enhance democracy and seek to limit major abuses of power. These mechanisms and associations include public, private, and nonprofit mechanisms and associations which seek to audit, verify, and certify, such as traditional government audit offices and commissions, private certifiers, and nonprofit organizations (e.g., Transparency International, the Sunlight Foundation in the United States, and GetUp in Australia). These mechanisms and associations can and do work together to constitute new forms of countervailing power, with the potential to correct or at least keep in check the negative consequences of power asymmetry and abuse in polycentric climate governance.

CONCLUSIONS AND FUTURE CONTRIBUTIONS OF A POWER-CENTERED FRAMEWORK

Models and theories of polycentric governance are making substantial headway on issues of innovation, trust, scale, and knowledge.[8,105–108] Here we emphasize that all of these issues are illuminated by inclusion of power dynamics and that such inclusion increases the explanatory power of these models. We argue that while dominant conceptualizations of polycentric governance provide useful insights into the potential for climate mitigation and adaptation, present models downplay the powerful roles of higher levels including those of the nation state, as well as the more diffuse exercise of power at lower levels of governance. We are not implying that the state always plays the most powerful hand or that there is an underlying model for how power should be most effectively structured. Indeed, decades of research on federalism, decentralization, and international relations have shown that even in the presence of strong systems, horizontal and vertical cooperation is difficult.[76,109,110] Rather, we argue that it is critical to understand how different actors mobilize power and authority in polycentric systems in order to bring about transformational change.

Many studies of polycentrism focus on visible examples of decentralization and experimentation. These are often presented as complex yet politically benign structures; for example, network structures that rely on soft interventions such as information sharing, devolution of responsibilities, and fiscal incentives. Yet, despite their complexity and benign

appearance, polycentric governance systems continue to emerge spontaneously in response to environmental dilemmas and are often exciting in terms of how they invoke different sources of power to achieve or avoid collective goals. In our categorization, we suggest that pragmatic power and framing power may be the dominant modes through which collective goals in polycentric systems are sought and sometimes achieved.

We have highlighted how three specific elements of power—power by design, pragmatic power, and framing power—imbue different levels of actors and arrangements with the authority to realize collective goals in polycentric governance systems. Further research is needed to explore many of the issues raised in this review. First, it is important to be clear and specific on what makes polycentric governance distinctive, and to identify how embedded and prevalent it is in all governance structures. Second, it is necessary to track how power dynamics within polycentric governance systems change over time. A significant research task is the development of methods capable of monitoring different elements of power. Many policy analyses focus on short time frames of four to six years.[80] However, we suggest that a longer time frame is more suitable for an analysis of the capillary nature of power as it shifts over time.[37,59,69] A third analytical task suggested by our review is the clarification of causality in study design: is power an inevitable outcome of governance structures or independent of such structures?[111] Settling such methodological questions would facilitate the building of a significant evidence base on the presence, effectiveness, and distributional impacts of polycentric governance. There is also the more normative question of how power should be most effectively structured in particular polycentric systems; for instance, should it be evenly distributed, or should the weakest actors have veto power? These are important questions for further research.

At the heart of this scientific debate is the issue of whether interactions between different actors in polycentric systems actually improve the prospects of dealing with the dilemmas of climate change. The promise is that polycentric systems bridge the divide between hierarchical structures and the lack of agency involved in both adaptation and mitigation efforts. By promoting detailed analysis of power, we argue that the failures of polycentric systems to deliver on their promise can be at least partially explained, and perhaps that recognizing such power can aid in better governance to avoid the constraints and pitfalls of the capture of structure by certain interests. Ultimately, future development, implementation, and practice would be enhanced by recognizing how power is mobilized to achieve goals, and in whose interest it is exercised.

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