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# Climate change adaptation, social capital, and the performance of polycentric governance institutions

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## Abstract

How do patterns of interactions among policy actors shape their ability to contribute to climate change adaptation decision-making processes in fragmented regional governance settings? We address this question through statistical models of adaptation policy actors' assessments of access to scientific/technical information as well as their perceptions of cooperation and procedural fairness across numerous adaptation decision-making processes operating in the Lake Victoria region, East Africa. We measured actors' collaborative interactions as well as their participation in task forces, steering committees, and other policy forums that have emerged in response to the challenges of building adaptive capacity to the effects of climate change in the region. Because information access, cooperation, and procedural fairness are shaped by social processes, we tested how the performance of policy forums varied according to different measures of social capital. Specifically, we distinguished between bridging social capital (the value of relationships that span or broker between distinct subgroups) and bonding social capital (which results from frequent interaction or from clustered relationships within subgroups). We found that measures of bridging social capital had a positive effect on actors' assessments of their access to information in policy forums, but a negative effect on their perceptions of cooperation and procedural fairness in forums. In contrast, measures of bonding social capital had a positive effect on cooperation and procedural fairness, but no effect on information access. Taken together, our results suggest that different forms of social capital have separate—and potentially opposing—effects on distinct measures of the performance of adaptation policy forums. The relative importance of each performance measure, which may vary from one policy forum to another, should guide efforts to encourage different forms of social capital across the numerous decision-making processes that comprise regional climate change adaptation governance systems.

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## 1 Introduction

This paper focuses on the question of how policy networks constitute a form of social capital that affects how actors perceive the performance of governance institutions for climate change adaptation in the Lake Victoria region in East Africa. This study system, which extends over of portions of Uganda, Kenya, and Tanzania, features significant adaptation challenges that span administrative boundaries, economic sectors, and diverse ethnic groups (Vervoort et al. 2014). Similar to other complex social-ecological settings, the Lake Victoria climate change adaptation governance system is polycentric (Ostrom et al. 1961; Ostrom 2010; Lubell et al. 2014; Berardo et al. 2015), in the sense that it features numerous decision-making processes with overlapping jurisdictions and mandates. While such settings are characterized by the fragmentation of authority at regional scales, there is extensive interdependence among the individual decision-making processes, which we refer to as "policy forums," that comprise the overall governance system. This paper investigates how actors' assessments of the performance of these forums depend upon how actors and forums are embedded in the broader adaptation policy network.

Our analysis builds on several core ideas that are essential for understanding climate change adaptation in polycentric systems. First, we recognize adaptive capacity as an emergent outcome of localized interactions distributed across polycentric governance systems (Folke 2006; Pelling et al. 2008; Levin 2003). For example, in the Lake Victoria region, one form of interaction involves relationships among actors that collaborate in projects and programs designed to address adaptation issues. Actors are also linked to decision-making processes via their participation in policy forums. One way to conceptualize polycentric adaptation governance is as an "ecology of games" (Lubell 2013; McAllister et al. 2013), in which "games" refers to stakeholders participating in policy forums (e.g., task forces, steering committees, legislative processes) where they collectively make decisions about the design and implementation of adaptation policy. The fragmented distribution of authority characteristic of these systems defies top-down management (Andersson and Ostrom 2008). For example, in governance systems characterized by multiple formal and informal collaborative policy forums with overlapping jurisdictions and participants, no single centralized institution can force actors to cooperate with one another to design and implement adaptation policies in the most efficient manner. Rather, successful adaptation hinges upon self-organization and the collective performance of these (potentially numerous) decision-making processes operating within a given region (McAllister et al. 2013).

Second, the evaluation of how polycentric institutions contribute to adaptive capacity requires assessment of three core functions of policy processes: policy learning, cooperation, and resource distribution (Lubell 2013). The exchange of scientific/technical information among diverse stakeholder groups enables policy learning and reduces uncertainty associated with projected climate change impacts as well as prospective outcomes of adaptation actions (Haug et al. 2009; Heikkila and Gerlak 2013). Collaboration among policy actors generates norms of reciprocity and trust, which enable actors to cooperate to design and implement policies (Potoski and Prakash 2004; Leach and Sabatier 2005). The legitimacy of these policies also hinges upon the procedural fairness of decisions about the distribution of the costs and benefits of climate adaptation policy, particularly in settings that feature historically marginalized groups and/or entrenched interests (Adger et al. 2003; Adger et al. 2006; Morrison et al. 2017; Alexander et al. 2018). Political power shapes the fairness of polycentric governance, because policy actors make decisions about who can participate in bargaining over the distribution of costs and benefits. The ecology of games framework stresses the importance

of examining all three of these processes simultaneously across the system, rather than in isolation (Lubell 2013).

Third, policy networks are a crucial form of *social capital*—i.e., the value of relationships (Baker 1990; Ostrom 1994; Knoke 1999; Koliba et al. 2011)—which influences how stakeholders participate in and contribute to decision-making processes. Climate change adaptation decision-making is an inherently social process, and relationships among stakeholders have bearing on the scope and scale of the adaptation policies they collectively develop (Adger 2003). Consequently, the performance of adaptation decision-making processes depends on stakeholders' abilities to draw upon social capital as they navigate fragmented governance systems. However, different forms of social capital may influence performance in different ways, with potential tradeoffs. There is evidence that transitive and overlapping relationships indicative of *bonding social capital* help actors engage in partnerships that require trust, for example, in high-stakes decision-making processes prone to conflict (Coleman 1988; Berardo and Scholz 2010; Berardo and Lubell 2016). By contrast, broad and diverse relationships reflective of *bridging social capital* have been associated with learning and innovation because they provide exposure to new information and other resources (Burt 2005; Berardo and Scholz 2010). Social capital is therefore important for understanding both the structure of policy networks (e.g., how actors draw upon relationships to access information), as well as their function (e.g., how resulting patterns of information exchange shape the design of policy).

By linking measures of the performance of adaptation policy forums to the patterns of interactions that characterize actors' involvement in the overall adaptation policy process, we contribute to the development of an understanding of how climate change adaptation governance systems function. In particular, we develop a series of hypotheses about how different types of social capital shape actor assessments of distinct measures of forum performance. We test these hypotheses using data from a survey of actors participating in climate change adaptation policy forums in the Lake Victoria region in East Africa. Our survey prompted adaptation policy actors to identify their collaborators as well as the forums in which they participate. Additionally, actors assessed the performance of those forums in terms of information access, cooperation, and procedural fairness. In the following sections, we describe how these performance measures are linked to adaptive capacity and we present the theoretical rationale for our hypotheses about how each is shaped by social capital. After explaining our methodology, we present our results and discuss the implications of our findings for adaptation governance in the Lake Victoria region as well as other polycentric governance systems.

## 2 How information access, cooperation, and procedural fairness shape adaptation policy processes

The success of adaptation policy processes hinges upon how well they enable actors to overcome numerous and linked collective action problems (Adger et al. 2005a). The spatial scale of hazards such as flooding and drought requires not only horizontal coordination of information and resources across socially and ecologically heterogeneous landscapes, but also cross-level, vertical coordination from the local to global levels of policy-making (Urwin and Jordan 2008; Hamilton et al. 2018; Taylor and McAllister 2013; Paavola et al. 2009; Young 2002). The complex and potentially contentious settings in which adaptation policies are designed and implemented further increases the need for cooperation among diverse stakeholder groups (Few et al. 2007; Baird et al. 2014). The goal of achieving an equitable

distribution of costs and benefits among stakeholder groups and constituencies in adaptation policy constitutes an additional reason why collective action is necessary, particularly given the changes in political authority that often accompany the integration of adaptation planning into existing policy sectors such as agriculture, health, and energy (Kates 2000; Huq et al. 2004). Drawing upon theories of collaborative governance, we focus on information access, cooperation, and procedural fairness as process-based performance indicators (Lubell 2013).

### 2.1 Access to scientific/technical information

Although important in all governance settings, access to policy-relevant information is especially critical for climate change adaptation, given the high level of scientific/technical uncertainty that characterizes efforts to evaluate the prospective outcomes of various policy alternatives. Particularly critical is the availability of "usable knowledge" (Kalafatis et al. 2015; Lemos 2015). Usable knowledge is often based on scientific research that policy actors perceive as technically sound and is communicated in a format that is accessible to decision-makers. In decision-making settings characterized by stakeholder groups with diverse policy preferences, actors may draw upon different sources of information in support of their positions. Their ability to gain support from other actors hinges upon their access to credible information, which is commonly grounded in scientific or technical assessments. Additionally, the prospect of rapid environmental change requires a balance between policies designed to anticipate future conditions and policies that can be redesigned or implemented in different ways in response to new information (Wildavsky 1988; Tschakert and Dietrich 2010). As a result, the outcomes of adaptation policy processes hinge not only upon the quality of scientific/technical knowledge accessible for the design of adaptation policies, but also the availability of knowledge at multiple points in time when policies are iteratively improved or completely reformulated. The processes that facilitate these reflexive forms of policy-making are themselves shaped by interactions among diverse groups of actors in formal and informal policy networks (Pahl-Wostl 2009).

### 2.2 Cooperation

The capacity of policy actors to solve collective action problems reflects their ability to secure the mutual benefits of cooperation. In the context of climate change adaptation, cooperation might entail policy actors' willingness to exchange data or knowledge with one another (Osman-Elasha and Downing 2007; Huntjens et al. 2012), their joint contribution to the development of plans or strategies (Moser and Ekstrom 2010), or their commitment of financial, material, or human resources towards other collaborative endeavors. Given the scale and scope of adaptation challenges, the success of policy interventions hinges upon collective contributions from large and often diverse groups of actors, highlighting the importance of strong mechanisms for cooperation. For example, in their study of actors participating in climate change adaptation decision-making processes, Baird et al. (2014) found that greater interaction among actors enhanced their ability to cooperate.

### 2.3 Procedural fairness

Uneven distribution of vulnerability across geographic regions and sectors of society highlights the importance of considering how policy processes reflect the diversity of policy preferences among actor groups (Cannon 1994; Paavola and Adger 2002). Policy processes

that lack robust norms of procedural fairness may perpetuate historical inequalities and deepen the vulnerability of populations that are already marginalized. For example, while industrialized agricultural development, hydroelectric projects, and similar large-scale initiatives may achieve certain adaptation goals, they may do so at the expense of local communities, indigenous groups, and other populations that are already highly exposed to the effects of climate change (Kates 2000). Scale-dependent power asymmetries similarly highlight the importance of fairness in decisions about the distribution of costs and benefits of adaptation. The scale of adaptation challenges requires policy responses that span multiple spatial/administrative levels (Moser and Ekstrom 2010). These multi-level decision-making processes bring together actors of varying levels of capacity and influence, and often feature power dynamics that favor higher-level actors at the expense of lower-level actors (Adger et al. 2005b; Gallemore et al. 2015; Hamilton 2018). Given the diversity of actors with a stake in adaptation outcomes, the fairness of decision-making processes shapes the legitimacy of their outcomes (Adger 2006; Pettersson et al. 2017; Alexander et al. 2018). The pursuit of procedural fairness is not only a normative goal. Actors who are satisfied with the level of procedural fairness are also more likely to cooperate (Tyler and Blader 2002). Furthermore, over the long run, policy systems that are widely perceived as inequitable will be less resilient if policy actors decide to exit the system or engage in major disruption (Hirschman 1970).

Access to scientific/technical information, cooperation, and procedural fairness shape the performance of climate change adaptation policy processes. In turn, these performance measures are themselves shaped by the manner in which policy actors interact with one another in decision-making settings, or policy forums. The following section outlines how different forms of social capital associated with these patterns of interactions may influence the degree to which a given forum can facilitate information access, cooperation, and procedural fairness.

## 3 How social capital shapes information access, cooperation, and procedural fairness

Social capital refers to actors' capacities to individually or collectively benefit from relationships (Baker 1990; Knoke 1999). Scholars often distinguish between bridging and bonding social capital (Putnam 2000; Narayan-Parker 1999; Onyx and Bullen 2000). Bridging social capital refers to the ability to broker among and access resources from diverse actor groups, who are more likely to provide non-redundant information and opportunities. Relationships associated with bridging social capital may be "weak" in the sense that they do not require frequent interaction or substantial resource commitment from either party (Granovetter 1973). However, these ties can facilitate innovation as well as the efficient coordination of information (Burt 2005). For this reason, bridging relationships have been linked to greater access to information across a variety of settings, including corporate management (McEvily and Zaheer 1999), online social networks (Ellison et al. 2007), and natural resource management (Newman and Dale 2005; Ramirez-Sanchez and Pinkerton 2009). Consequently, we predict:

H1: Bridging social capital will be positively associated with information access.

By contrast, bonding social capital facilitates forms of collective action that require strong norms of trust, reputation, and monitoring of behavior. The "strong" relationships associated with bonding social capital develop through overlapping/redundant connections as well as

through repeated interaction. In particular, the types of relationships associated with bonding social capital function to help actors engage in complex and potentially high-stake negotiations by providing mechanisms to prevent defection (Coleman 1988). In a study of how stakeholders seek to solve watershed management collective action problems in which the risk of defection was high, Berardo (2014a) found a strong tendency for stakeholders to engage in the types of redundant, overlapping relationships indicative of bonding social capital. The relationship between repeated interaction and cooperative outcomes has been demonstrated in a variety of theoretical and empirical settings (Axelrod 1984; Kreps et al. 1982; Cardenas et al. 2004). In addition to facilitating cooperation, bonding social capital has also been linked to the development of norms of fairness, which depend in part on norms of reciprocity and trust. Through institutionalization of these norms, for example via repeated interactions among the same group of actors, actors become increasingly "inequity-averse" (Fehr and Schmidt 1999). In a comparison of collaborative networks of stakeholders involved in management of estuaries, Schneider et al. (2003) found that networks involved in the National Estuary Program, which were characterized by stronger interpersonal ties between stakeholders, were also more positively assessed in terms of procedural fairness. Our second hypothesis encapsulates these expectations about the value of bonding social capital:

> H2: Bonding social capital will be positively associated with cooperation and procedural fairness.

While our first two hypotheses focus on the benefits of bridging and bonding relationships, both forms of social capital may help actors achieve certain goals at the expense of others. Although bridging social capital may facilitate access to information, it may limit cooperation. Bridging relationships span communities that are otherwise weakly connected. As a result, there are fewer opportunities for monitoring and enforcing the extent to which actors follow through on cooperative agreements, which exposes actors to higher risk of defection (Berardo and Scholz 2010). Because bridging relationships extend across broad regions of a network, they may likewise span groups of actors with varying levels of resources and authority, which increases the prospects for power asymmetries among actors (Weiss et al. 2012; Adger et al. 2005b). Under these conditions, decision-making processes may feature broad representation but limited opportunities for less powerful actors to contribute in meaningful ways to decisions (Ernstson et al. 2008). Consistent with these ideas about the implications of bridging relationships, we expect:

> H3: Bridging social capital will be negatively associated with cooperation and procedural fairness.

Correspondingly, bonding social capital may constrain information access. Strong and overlapping relationships provide a mechanism for the reinforcement of existing beliefs and may limit exposure to diverse ideas (Newman and Dale 2007) and may inhibit innovation (Gabbay and Zuckerman 1998). Cohesive subgroups with high bonding social capital may exclude other actors (Portes 1998), who may have access to diverse resources, including information.

> H4: Bonding social capital will be negatively associated with information access.

The implications of these trade-offs between both forms of social capital underpin the "risk hypothesis" advanced by Berardo and Scholz (2010), which argues that the relative value of

bridging versus bonding social capital depends on the nature of the collective action problems that dominate a given policy setting. Relationships associated with bridging social capital are more prevalent in low-risk policy settings in which key challenges involve coordination problems, rather than conflict resolution (Berardo and Scholz 2010). In high-risk settings, bonding network capital should be more common (Berardo 2014a). In a departure from prior tests of the risk hypothesis, which have distinguished between high and low risk at the level of a given study system (Berardo and Scholz 2010; Berardo 2014a) or stakeholder group (Feiock et al. 2012; McAllister et al. 2015), we focus on how bridging/bonding social capital shape actor assessments of information access, cooperation, and procedural fairness at the level of specific climate change adaptation policy forums. Our analysis highlights the ecology of games argument that polycentric systems must enable multiple social processes, and the potential complements and trade-offs among them.

## 4 Methods

### 4.1 Study system: climate change adaptation governance in the Lake Victoria region

We study information access, cooperation, and procedural fairness in climate change adaptation policy processes operating in the Lake Victoria region, East Africa (Fig. 1). The region is projected to experience a range of climate change adaptation challenges, including shocks to climate-sensitive sectors such as small scale agriculture (Thornton et al. 2009a; Jones and Thornton 2009), rangeland systems (Thornton et al. 2009b; Bond and Midgley 2012), and small-scale fisheries (Ficke et al. 2007; Hecky et al. 2010).

One reason why these challenges are so difficult to address is considerable scientific uncertainty about the scope of climatic changes the region is projected to experience, as well as technical/policy uncertainty about prospective outcomes of various adaptation actions and


**Fig. 1** Map of the Lake Victoria region in East Africa, with fieldwork locations indicated

other policies (Adger et al. 2003). Cooperation dilemmas pose additional challenges for building adaptive capacity, and stem in part from the transboundary nature of the system along with the diversity of actors that participate in climate change adaptation policy processes. In the Lake Victoria region, these actors include governmental organizations, civil society organizations, international non-governmental organizations, development partners (donors), academic/research centers, private corporations, and intergovernmental organizations such as the East African Community. The degree to which these actors pursue cooperative versus self-interested objectives in policy settings will profoundly shape adaptation outcomes (Chaudhury et al. 2012; Vervoort et al. 2014).

Another source of collective action problems relates to the need to "mainstream" climate change adaptation into existing policy arenas (Huq et al. 2004). Although the governments of Kenya, Uganda, and Tanzania have each designated a single body that coordinates activities related to climate change, adaptation planning has been integrated into the responsibilities of numerous ministries, departments, directorates, and other governmental organizations. The resulting reconfiguration of policy mandates highlights the need for procedural fairness in high-level decisions concerning the allocation of political authority and financial resources. Even when newly established institutions provide opportunities for broader participation, they may still retain hierarchies that concentrate power and influence among international organizations and government ministries at the expense of civil society organizations, which have been historically marginalized in decision-making processes in many developing regions (Bäckstrand 2008; Amutabi 2013). Under these conditions, decision-making processes regarded to be fair can help to mitigate the effects of preexisting power asymmetries (Few et al. 2007).

### 4.2 Data collection

From February to August 2014, we administered a survey to representatives of organizations that participate in climate change adaptation policy forums in the Lake Victoria region. We treated these organizations as actors. We collected data using a purposive sampling approach in which organizations were identified through a two-stage process: we first developed a list of organizations using a combination of Internet search and review of relevant documents. This list was then reviewed and extended by members of a steering committee of regional experts from Uganda, Kenya, and Tanzania. The list included only formal organizations (i.e., with staff and headquarters). We identified survey respondents in a similar fashion: based on organization websites, online meeting notes, and other documents, we developed a list of names and contact information, which steering committee members reviewed and extended. The resulting list of individuals included climate change adaptation focal persons (typically for larger organizations) or administrative personnel (such as program managers or executive directors) who were familiar with their organizations' activities related to climate change.

We primarily administered the survey in person, at respondents' places of work. This entailed conducting visits of between 2 and 6 weeks to cities where respondents' organizations were located. These cities included Kampala, Entebbe, and Jinja in Uganda; Nairobi and Kisumu in Kenya; and Dar es Salaam, Arusha, and Mwanza in Tanzania (Fig. 1). Due to scheduling complications, we were not able to administer the survey in person to several respondents who indicated their willingness to participate in the research project. These individuals were sent a link to complete a web-based version of the survey. In the end, we surveyed representatives of 125 organizations using the in-person instrument and 19 organizations using the web-based instrument. For three large organizations, we surveyed two

representatives. As our initial list of climate change adaptation policy actors included 245 actors, our response rate was 59%.

### 4.3 Variables and analytical approach

Because our research questions concerned how actors assess the performance of forums in which they participate, our unit of analysis was the actor-forum dyad. These dyads were embedded in network structures involving other actors and forums. In subsequent descriptions of the variables we used to evaluate actor assessment of forum performance, we use "focal actor" and "focal forum" to distinguish between members of the actor-forum dyad (i.e., the forum assessed by the actor) and other actors and forums linked to the dyad via patterns of collaboration or participation.

Our survey defined forums using the following language: "Climate change adaptation can be addressed in different kinds of projects, programs, forums, or planning processes where multiple organizations collaborate to make decisions about the design and implementation of climate change adaptation activities." The survey then prompted respondents to identify up to 12 forums in they participated. This process elicited 565 actor-forum dyads involving 324 unique forums. Many of these forums were peripheral to the Lake Victoria climate change adaptation governance network and were only identified by one respondent. We focused on the subset of forums identified by at least two respondents, which allowed us to study dynamics operating in the core of the policy process. Additionally, several of our key independent variables were only relevant for forums in which at least two actors participate. After excluding peripheral forums, our dataset comprised 325 actor-forum dyads involving 125 actors and 84 forums, in which actors participated in an average of 3.0 forums and an average of 3.9 actors participated in each forum.

For each forum identified by each respondent, our survey also asked the respondent to assess how well the forum facilitated information access, cooperation, and procedural fairness. These three indicators of forum performance comprised our dependent variables. We measured *Access to Information* using the following question: "In each initiative, how frequently do you think relevant scientific/technical information is readily available for decision-making?" To measure *Cooperation*, we asked: "Overall, how would you describe cooperation between organizations participating in each initiative?" For both variables, response categories included *Never*, *Rarely*, *Sometimes*, *Usually*, *Always*, and *do not know*. We measured *Procedural Fairness* by asking: "In each initiative, how fair is the process of reaching decisions for all organizations involved?" Response categories included *Very unfair*, *Unfair*, *Neither fair nor unfair*, *Fair*, *Very fair*, and *do not know*. We coded responses on a 1–5 scale, with higher values representing more favorable assessments (i.e., 5 = *Always*), and treated *do not know* responses as missing values.

Given that social capital reflects patterns of interaction among actors, we drew upon the tools and perspectives of network science to measure our key independent variables. In particular, we grounded our analysis in an active literature that has linked certain network configurations to bridging and bonding social capital. Following Berardo and Scholz (2010), we refer to these as "bridging structures" and "bonding structures." The use of these network structures allowed us to evaluate our expectations about relationships between different forms of social capital and the performance of climate change adaptation policy forums (Table 1).

The variable *Frequency of Participation* measures how often actors participate in policy forums. For each forum, respondents indicated the frequency of their participation according to

**Table 1** Hypothesized effects of various bridging and bonding structures on access to information, cooperation, and procedural fairness. In each diagram, circles represent actors; squares represent forums. Dashed lines indicate actor participation in forums; solid lines indicate collaboration between actors. Each hypothesis focuses on actor *a*'s assessment of forum *f*

| Key independent variables | | Hypothesized effects on dependent variables | | |
|---|---|---|---|---|
| Structure (form of social capital) | Diagram | Access to Information | Cooperation | Procedural Fairness |
| Frequency of Participation (bonding) |  | − | + | + |
| Collaborative Closure (bonding) |  | − | + | + |
| Breadth of Participation (bridging) |  | + | − | − |
| Forum Popularity (bridging) |  | + | − | − |

the following response categories: *Daily*, *Weekly*, *Monthly*, *Quarterly*, *Annually*, and *do not know*. As with our dependent variables, we treated *do not know* responses as missing values. Because more frequent participation provides opportunities for actors to become more familiar with one another, we regarded this variable as an indication of bonding social capital. Another measure of bonding social capital was the variable *Collaborative Closure*. This variable is a count of the number of actors that collaborate with the focal actor that also jointly participate in a given forum. To identify collaborators, survey respondents were asked to "list the organizations your organization has collaborated with in the context of climate change adaptation in the past year." We regard this set of relationships as a bonding structure because it measures closure—the collaborative relationship between the focal actor and each joint participant provides opportunities to monitor those actors, which serves as a check against defection or other uncooperative behavior (Berardo and Scholz 2010).

We included several different measures of bridging social capital. The variable *Breadth of Participation* is a count of the number of policy forums in which the focal actor participates, in addition to the focal forum (i.e., the forum the actor is assessing). Following Berardo (2014b), we regard this variable as an indication of bridging social capital, because it reflects the focal actor's capacity to broker among multiple forums and access diverse information and other resources. Correspondingly, *Forum Popularity* is a count of the number of other actors that participate in the focal policy forum, which represents bridging social capital in the sense that each additional participant's contribution to policy-making processes may broaden the collective stock of information, knowledge, and other resources accessible to the focal actor. Although Berardo (2014b, p. 202) describes the *Forum Popularity* variable as a "weak bonding structure" we believe

that the structure may reflect both forms of social capital, depending on the level of analysis. At the level of the governance system, forums with many participants may provide opportunities for those actors to become familiar with each other (this very dynamic is captured in the variable *Collaborative Closure*). However, from the perspective of an individual actor participating in a particular forum, additional participants do not necessarily enhance the development of norms of trust and reciprocity.

We included several additional variables (Table 2) that were not directly related to our hypotheses, but have been shown to be important predictors of how actors assess forum performance and how they interact with one another in collaborative policy-making settings (Berardo 2014a; Lubell et al. 2014, 2017; Hamilton and Lubell 2018). *Collaborative Activity* measures the total number of actors with which the focal actor collaborates. *Actor Influence* is a count of the number of times the actor was nominated by other actors in response to the following question: "Out of all the organizations involved with climate change adaptation issues in the Lake Victoria region, please list up to 6 that you believe are most influential (excluding your own organization). Please also consider organizations that your organization does not collaborate with." *Forum Level* and *Actor Level* measure the administrative level at which forums and organizations operate, respectively. The variable *Governmental Actor* indicates whether the focal organization is a ministry or other governmental body. Finally, we included the interaction term *Collaborative Activity * Actor Influence* to account for the possibility of a relationship

**Table 2** Other independent variables. In each diagram, circles represent actors; squares represent forums. Dashed lines indicate actor participation in forums; solid lines indicate collaboration between actors; dotted arrows indicate nominations of actor *a* as influential. Shading indicates whether values were measured for actor *a* or forum *f*

| Variable | Diagram | Scale | Value(s) |
|---|---|---|---|
| Collaborative Activity |  | Continuous | Number of actors with which actor *a* collaborates |
| Actor Influence |  | Continuous | Number of actors that consider actor *a* to be influential, as indicated by the dotted arrow |
| Forum Level |  | Ordinal | 1=Subnational<br>2=National<br>3=Lake Victoria Regional<br>4=Continental<br>5=Global |
| Actor Level |  | Ordinal | 1=Subnational<br>2=National<br>3=Lake Victoria Regional<br>4=Continental<br>5=Global |
| Government Actor |  | Binary | 0=No<br>1=Yes |

between an actor's breadth of collaboration and the number of times the actor was nominated by other actors as influential.

We estimated a separate ordinal logistic regression model for each of the three dependent variables. Although we measured each of these variables on a 1–5 scale, a linear regression would not have been appropriate given the ordinal nature of values for these variables (e.g., 1 = *Never*, 2 = *Rarely*). As we note in Section 5.1, these variables were not normally distributed, which supports the appropriateness of ordinal logistic regression. As our unit of analysis is the actor-forum dyad, many individual actors and forums appear multiple times; following Lubell et al. (2017), we address the potential for autocorrelation by using robust standard errors clustered for actors as well as forums. We further examined the robustness of our results using permutation tests (Table S1).

## 5 Results and discussion

### 5.1 Overall assessments of forum performance

Responses were not normally distributed, and skew towards more positive assessments of forums (Fig. 2). Most respondents stated that scientific/technical information was *Sometimes*, *Usually*, or *Always* used for decision-making. Similarly, most respondents indicated that organizations *Sometimes*, *Usually*, or *Always* cooperate in forums. Most also stated that processes for decision-making processes were either *Fair* or *Very fair*.

### 5.2 Positive effects of social capital

We report results of our ordinal logistic regression models in Table 3. Because we tested each hypothesis with several measures of each form of social capital, Table 4 provides a qualitative summary of the results relative to our hypotheses. In general, results provided support for our hypotheses that bridging social capital would be important for access to information (H1) while cooperation and procedural fairness would depend upon bonding social capital (H2).

We found a positive effect between *Forum Popularity*—an indicator of bridging social capital—and actors' assessments of access to information. The variable *Breadth of Participation* was not a significant predictor of information access, possibly because we measured this variable separately for all forums in which each actor participates. Participation in many forums may indeed afford broad access to knowledge, information, and expertise, but these benefits might not necessarily improve opportunities to access information in any given forum.

Perceptions of cooperation and procedural fairness were positively associated with actors' *Frequency of Participation* in policy forums. Estimates for the *Collaborative Closure* variable show that actors reported greater cooperation in forums in which their collaborators also participated. In particular, the frequency with which an actor participated in a given forum seemed to provide the "thick" trust (Newton 1997) necessary for sustaining cooperation. Similarly, our finding that actors perceived more positive cooperative outcomes in forums in which their collaborators also participated is consistent with environmental governance theories that link network closure with decreased need for monitoring and enforcement, which in turn reduce the transaction costs of cooperation (Berardo and Scholz 2010). We did not find

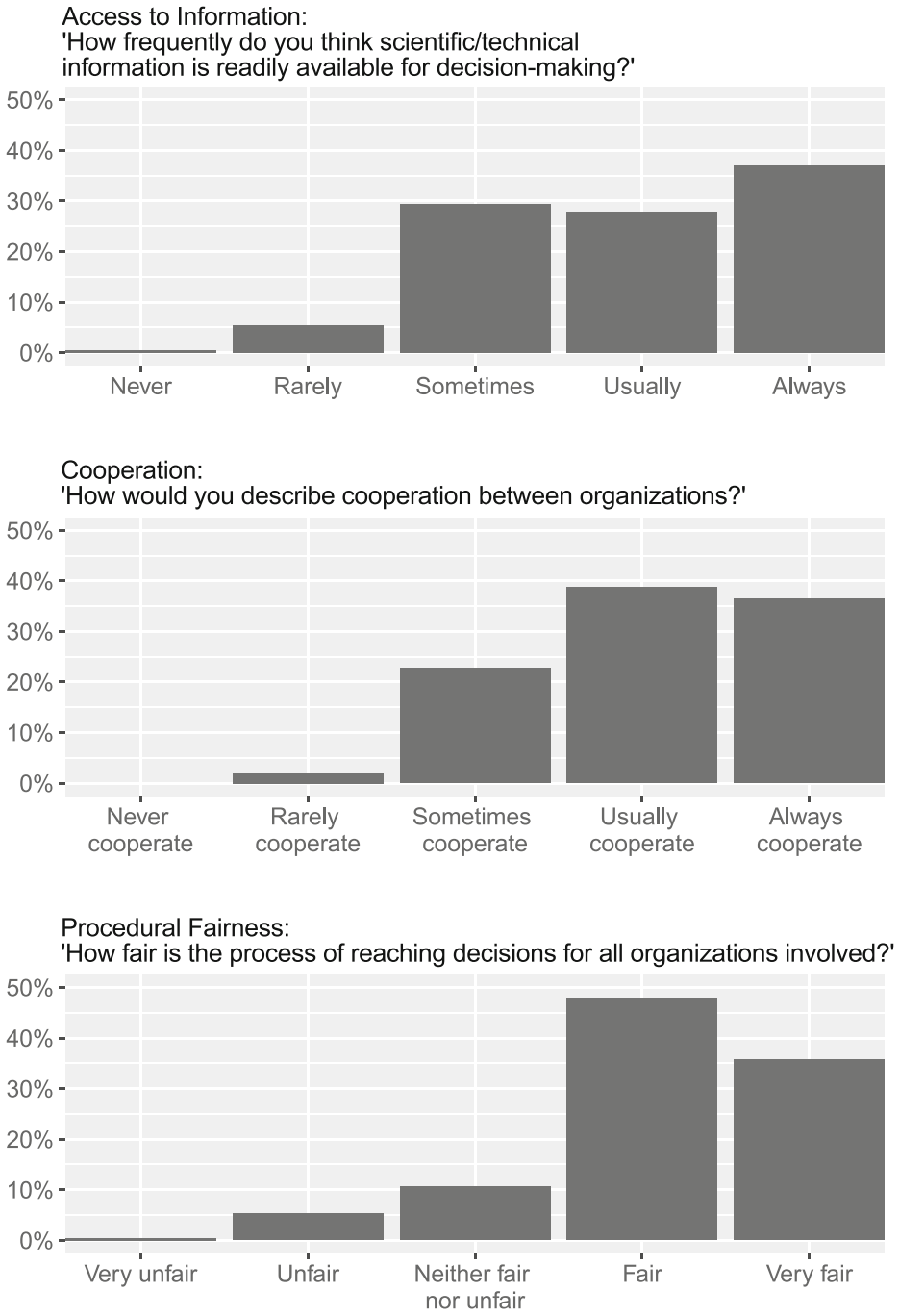


**Fig. 2** Distribution of responses for each of the dependent variables

support for our expectation that this measure of bonding social capital would be positively associated with perceived procedural fairness.

**Table 3** Models of climate change adaptation forum performance

| | Access to information | Cooperation | Procedural fairness |
|---|---|---|---|
| Bonding social capital | | | |
| Frequency of participation | 0.13 (0.09) | 0.42 (0.11)*** | 0.64 (0.12)*** |
| Collaborative closure | −0.05 (0.12) | 0.34 (0.09)*** | 0.11 (0.09) |
| Bridging social capital | | | |
| Breadth of participation | −0.02 (0.10) | −0.09 (0.06) | −0.21 (0.07)** |
| Forum popularity | 0.05 (0.02)** | −0.06 (0.02)*** | −0.05 (0.01)*** |
| Control variables | | | |
| Collaborative activity | 0.12 (0.04)** | 0.01 (0.04) | −0.01 (0.04) |
| Actor influence | −0.08 (0.11) | −0.07 (0.12) | 0.27 (0.13)* |
| Forum level | 0.28 (0.10)** | 0.20 (0.12) | 0.07 (0.10) |
| Actor level | 0.00 (0.21) | 0.24 (0.25) | 0.10 (0.18) |
| Governmental actor | −0.41 (0.44) | 0.88 (0.60) | 0.08 (0.49) |
| Collaborative Activity * actor influence | −0.01 (0.00) | 0.00 (0.00) | −0.01 (0.00) |
| McFadden's pseudo R-squared | 0.09 | 0.08 | 0.15 |
| ML (Cox-Snell) pseudo R-squared | 0.19 | 0.17 | 0.29 |
| Cragg-Uhler pseudo R-squared | 0.21 | 0.19 | 0.32 |
| Observations[1] | 241 | 242 | 242 |

Significance levels: *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Cell entries are non-standardized regression coefficients. Robust standard errors are reported in parentheses

[1] Observations deleted due to missingness: access to information model: 84; cooperation model: 83; procedural fairness model: 83

## 5.3 Negative effects of social capital

Just as we predicted that the benefits of bridging and bonding social would vary according to the particular measure of the performance of climate change adaptation forums, we also expected to find trade-offs associated with each form of social capital. Indeed, results provide partial support for our hypothesis that actors would assess cooperation and procedural fairness more negatively in forums in which their participation involved greater bridging social capital (H3). The *Breadth of Participation* estimates indicate that actors that participated in more forums had more negative perceptions of the procedural fairness of those forums. Similarly, we found *Forum Popularity* to be negatively associated with actors' assessments of cooperation and the fairness of decision-making processes. The forum popularity variable provided the strongest indication of a trade-off between the costs and benefits of bridging social capital, as it was a positive predictor of information access and had a negative effect on both cooperation and procedural fairness. In other words, high participation may provide access to diverse sources of information and other resources, but at the cost of the efficiency with which actors work together as well as the fairness of decision-making processes. These results may also

**Table 4** Effects of bridging and bonding social capital on information access, cooperation, and procedural fairness. Asterisks indicate results significant at the 0.05 level. Hypothesized effects are provided in parentheses

| Key independent variable | Form of social capital | Access to information | Cooperation | Procedural fairness |
|---|---|---|---|---|
| Frequency of participation | Bonding | + (−) | + (+)* | + (+)* |
| Collaborative closure | Bonding | − (−) | + (+)* | + (+) |
| Breadth of participation | Bridging | − (+) | − (−) | − (−)* |
| Forum popularity | Bridging | + (+)* | − (−)* | − (−)* |

highlight the role of power asymmetries among actors as well as forums. Highly popular forums may dominate other forums by monopolizing access to information—actors seeking information may be compelled to participate in these forums by virtue of the high number of other actors already participating. However, extensive participation may limit cooperation and procedural fairness, leading less powerful actors to seek alternative opportunities to contribute to policy-making through participation in less popular forums. The negative relationship between an actor's breadth of participation across multiple forums and perceived procedural fairness in each one may indicate a different type of trade-off: between deep (frequent) investment in one forum versus broad investment in many forums. These findings support the idea that the degree to which actors can collaborate with one another and participate in policy processes is constrained by limited resources (Lubell et al. 2010; Scott and Thomas 2015).

Results did not support our hypothesis that bonding social capital would have a negative effect on access to information (H4). In fact, the frequency of participation variable was positively (though not statistically significantly) correlated with information access. It is possible that because climate change adaptation governance in the Lake Victoria region is in relatively early stages of development, in which scientific/technical uncertainty is readily acknowledged to be high (Chaudhury et al. 2012; Shackleton et al. 2015), bonding social capital does not yet function to reinforce actors' prior knowledge and beliefs. However, future empirical work is needed to test this idea.

### 5.4 Control variables

The *Collaborative Activity* variable had a positive effect on access to information. *Actor Influence* was positively associated with perceptions of procedural fairness. Of the remaining control variables, only *Forum Level* was a significant predictor of forum performance, and results indicated that forums operating at higher administrative levels offered greater access to information.

## 6 Conclusion

The Lake Victoria region features numerous climate change adaptation policy forums, through which numerous policy actors collectively contribute to the design and implementation of adaptation policies. We have argued that region-level adaptive capacity is an emergent outcome of forum-level processes. This article's main contribution is advancing understanding of how the performance of these forums—in terms of information access, cooperation, and procedural fairness—hinges upon the separate and potentially opposing effects of different forms of social capital. Our findings strongly conform to the broad literature on social and policy networks regarding the differential benefits of bonding and bridging social capital. Yet in a departure from much of the existing literature that analyzes concepts like cooperation in isolation, we suggest that the performance and resilience of polycentric systems depends on their capacity to enable all three of these key social processes and effectively manage the trade-offs among them.

In light of these results, a key policy implication relates to the need to facilitate multiple policy processes that offer opportunities to capitalize on the distinct benefits of bonding versus bridging social capital, depending on the nature of the collective action problem at hand. As an example, for certain adaptation policy challenges (e.g., involving the redistribution of

resources among entrenched interest groups as part of efforts to mainstream adaptation planning), procedural fairness may be vital while information access may be less important. To improve the performance of adaptation policy forums that address these sorts of issues, efforts to incentivize more frequent participation among a relatively small group of decision-makers may be especially effective. In cases where information access is critical but cooperation or procedural fairness less is important (e.g., in task forces charged with distilling research about an emerging adaptation issue into policy-relevant findings), broad participation may lead to better outcomes. Commonly, some balance of bridging and bonding social capital may be ideal.

However, our results also highlight the potential for trade-offs and suggest that bridging and bonding social capital may not always be complementary (Newman and Dale 2005). This challenge may be particularly problematic in adaptation policy processes, which often pursue multiple objectives related to diverse climate change impacts, and for which information, cooperation, and procedural fairness are all important. One potential strategy for addressing trade-offs is to separate the workload of policy forums such that decision-making processes that rely most on access to information may develop distinctly from those that depend upon cooperation and procedural fairness (e.g., by breaking up policy forums, or creating subcommittees with well-defined responsibilities). Likewise, as climate change adaptation governance systems evolve, the design of policy forums must account for shifts in the relative importance of access to information, cooperation, and procedural fairness. To the extent that trade-offs exist, polycentric systems may need to emphasize different functional goals over time or among different policy forums. For example, bridging social capital may be crucial in policy forums addressing emergent issues, while cooperation and fairness may be more important as policy systems mature (Lubell et al. 2017). However, in some governance settings, the pace and scale of environmental change may compel policy responses that simultaneously require access to scientific/technical information, cooperation, and procedural fairness. Under these conditions, the trade-offs we documented may also help explain the difficulty of mounting policy responses that effectively address environmental challenges. For example, transformative adaptation (Kates et al. 2012) may require multiple governance functions enabled by different forms of social capital (e.g., large scale cooperation to implement policies based on new technologies).

The complex and polycentric nature of climate change adaptation governance systems requires a deeper understanding of how dynamics of individual decision-making processes—such as policy forums—together generate adaptation outcomes at regional scales. Analysis at the level of this "ecology" of policy forums (Lubell 2013) is not only important because of the collective contributions of numerous decision-making processes, but also because of the functional interdependence created when actor contributions to policy-making span multiple decision-making settings (Mewhirter et al. 2018). Our analysis of how different forms of social capital shape forum performance accounts for this interdependence, for example, by showing that broad participation in multiple forums lowers actors' assessments of the procedural fairness of a given forum.

However, we recognize considerable opportunities to build upon this understanding of how social capital shapes the performance of adaptation policy processes, by linking performance measures to policy outputs (e.g., projects, programs, strategies, and other specific adaptation actions) at the level of individual policy forums, as well as the regional level. In this respect, longitudinal studies could prove particularly useful for testing predictions about the implications of the ways in which actors collaborate and participate in decision-making processes. For

example, such an approach could link patterns of collaborative interaction with forum dynamics (e.g., levels of perceived cooperation), and in turn provide key insight into how these dynamics shape the scope of policies that result from decision-making processes. Ultimately, an understanding of the characteristics of policy networks that enable desirable adaptation outcomes is crucial for designing more effective adaptation interventions in complex governance settings.

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