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Network governance of the commons

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Abstract: The survival of the commons is closely associated with the potential to find ways to strengthen contemporary management systems, making them more responsive to a number of complexities, like the dynamics of ecosystems and related, but often fragmented, institutions. A discussion on the desirability of finding ways to establish so-called *cross-scale linkages* has recently been vitalised in the literature. In the same vein, concepts like adaptive management, co-management and adaptive co-management have been discussed. In essence, these ways of organizing management incorporate an implicit assumption about the establishment of social networks and is more closely related to network governance and social network theory, than to political administrative hierarchy. However, so far, attempts to incorporate social network analysis (SNA) in this literature have been rather few, and not particularly elaborate. In this paper, a framework for such an approach will be presented. The framework provides an analytical skeleton for the understanding of joint management and the establishment of cross-scale linkages. The relationships between structural network properties – like density, centralization, and heterogeneity – and innovation in adaptive co-management systems are highlighted as important to consider when crafting institutions for natural resource management. The paper makes a theoretical and methodological contribution to the understanding of co-management, and thereby to the survival of the commons.

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Keywords: Co-management, Commons, Governance, Networks, Social capital, Social network analysis

1. Introduction

To achieve sustainability – in environmental, economic, and social development – finding appropriate institutions and management systems is vital. Consequently, for contemporary policy makers, making social and ecological systems work in harmony should be considered a desirable undertaking. However, institutional variety is immense, not only in terms of property rights and mixtures thereof, but also in the ways different societies have chosen to organize human affairs.

Building institutions is a matter of trial and error, as no blueprint exists for the endeavour. However, research has progressed. We know more about how to 'cope' with the tragedy of the commons (Feeny et al. 1990; Ostrom 1999). Thus, there is no such thing as 'the best' institution that once and for all would secure a sustainable utilization of common resources (Ostrom 2005). Hence, the task has been described as 'the struggle to govern the commons' (Dietz, Ostrom, and Stern 2003, 1907). Overwhelming evidence suggests that top-down centralized systems are less suitable for this challenging task. Most societal problems are too complex to fit into the formal problem-solving structures of government. While administrative boarders, both between different levels of policymaking and different policy sectors, are delineated, societal problems are characterized by their cross-scale nature. They span time, geographic space, and certainly, administrative jurisdictions. While this applies to most policy areas, these features are more apparent within the area of natural resource management (Berkes 2002).

In order to meet these challenges, the search for appropriate institutional arrangements has resulted in the formulation of a variety of related concepts, *such as adaptive management, local adaptive management*, and *co-management* (Walters 1986, 1997; Plummer 2004; Olsson, Folke, and Berkes 2004; Carlsson and Berkes 2005). The idea is that, in order to cope with the complexity of natural resource systems, institutional arrangements and related management systems should incorporate different actors from different areas of society. Thus, an emphasis on the establishment of multi-actor structures, consisting of both public and private actors, is a common denominator. Another feature of this line of research is the perception of the state, a reorientation that is indicated by a focus on governance, rather than government. While the latter is associated with political-administrative hierarchy, governance is understood as a process by which policy is produced within multi-actor structures beyond a formal hierarchy (cf. Rhodes 1996; Pierre and Peters 2000). Thus, the state is considered one possible, but not necessarily the most important, actor in this process of governance.

The concepts of co-management and governance incorporate an implicit assumption about the establishment of social networks, based upon a different logic than political-administrative hierarchy. Briefly, these networks can be described as social structures made up by nodes (actors), which are connected via a multitude of links (e.g. in the form of information flows, exchanges of goods, legal relations, etc). There has been substantial research done in the area of social networks,

mainly within the fields of sociology and organizational studies. Issues like how and why networks are formed and in what ways they affect the policy-making process and its outcomes have been discussed (Flap, Bulder, and Volker 1988; Provan and Milward 1995, 2001; Borgatti and Foster 2003; Reagan and Zuckerman 2003; O'Toole and Meier 2004; Meier and O'Toole 2001). In this vein, the possible structural effect on performance has been addressed, often in association with the concept and role of social capital (Burt 2000; Borgatti, Jones, and Everett 1998). The basic idea of these projects is that certain network structures generates higher social capital, and thereby, result in an improved performance. However, except for some shining exceptions (e.g. Maiolo and Johnson 1989; Schneider et al. 2003; Bodin 2006), there have been few and not particularly elaborate attempts to incorporate social network analysis in the fields of political science and, in particular, resource management. Thus, we do not know well how performance might be associated with particular network features - like density, centrality, and heterogeneity. A reasonable hypothesis is that good performance is associated not only with the establishment of particular management networks, but also with how these are structured.

1.2. Aim, questions and disposition

In this paper, we set out to bring previous research about the network structure of social capital and the concept of co-management together. Drawing upon contemporary research on co-management and findings from the field of social network analysis, the underlying question to be answered is: What qualities should well-performing networks preferably possess to achieve sustainable governance of the commons? Presumably, the answer to this question is relevant for policymaking and the improvement of natural resources management.

The primary aim of this paper is to suggest an analytical framework for network studies of co-management of natural resources. Based upon previous knowledge about the qualities of co-management systems and network theory of social capital, a relationship between structure and performance will be hypothesised. What kind of structural features are likely to facilitate well-performing co-management systems? The paper will yield a theoretical and methodological contribution to the understanding of joint management and, thereby, to the survival of the commons.

The article is organized into three main sections. First, the concept of co-management will be discussed. Thereafter, social network theory will be addressed. How and in what ways does network structure matter for organizing functions and, thereby, for institutional performance? In the third and final section of this article, the two lines of research will be brought together and the structural aspects of co-management will be discussed.

2. Co-management as a network governance system

In spite of slightly different interpretations, co-management is normally understood as a process by which private and public actors cooperate, and share power, in order to solve problems related to natural resource management (Jentoft, McCay, and Wilson 1998; Carlsson and Berkes 2005). In the literature, co-management often has been described as a bipolar system of collaboration, typically comprised of an agreement between a community of resource users and the State. Questioning this image, Carlsson and Berkes (2005), sketched out alternative ways to perceive such relationships. Their message was that relationships might vary, both due to the extent of resource dependencies and the actual condition of exchange, which, in turn, is dependent upon formal legal jurisdictions, rules and norms. Drawing upon this reasoning co-management could best be understood as network governance systems, in which a variety of different actors, structured by different institutional arrangements, participate.

The advantage of regarding co-management systems as networks is that the complexity of real-life settings is acknowledged. Instead of considering the State as one coherent actor, the multifaceted character of the government is recognized. While State authority ranges vertically (from the central governmental level to the local level) and horizontally (through different policy sectors), it has many faces. Governmental actors who are involved in real-life co-management are likely to endorse different tasks and have different interests and goals. Therefore, speaking of the State as if it was one coherent actor, characterized by unity of power and 'unity of command' (Ostrom, V. 1991, p. 36) would be seriously misleading. The same goes for communities, which typically consist of many different individual positions, groups and organizations. Given this dual complexity, co-management essentially entails creating coherent networks for problem solving. We regard this as a process by which actors meet to pool their resources, and coordinate their actions, in order to address specific management issues. Within these network structures, both as a result of intended vs. non-intended action, specific arrangements evolve, structuring the actions among its members. To govern is to make rules that are binding for a set of actors. Accordingly, governance can be understood as a process, which 'includes the setting of rules, the application of rules, and the enforcement and adjudication of rules,' (Feeny 1988, p. 172). In this sense, well established co-management systems (i.e., arrangements having some degree of durability) should be acknowledged to be systems, or networks, of governance.

2.1. The characteristics of a successful co-management system

Many theoretical arguments for why co-management should promote sustainable handling of resources can be found in the literature. Drawing upon Pinkerton's (1989) influential work, Carlsson and Berkes (2005) discuss six features that are associated with highly functioning co-management systems. These systems are

thought to improve the exchange of resources and have the ability to link different levels of organizations that are not necessarily formally connected. Co-management can, from this perspective, be perceived as a web of resource dependencies spanning a diversity of different organizations and hierarchical levels (compare the idea of *cross-scale linkage,* in Berkes 2002). Additionally, the great variety in skills and competence among those involved is assumed to refine the allocation of tasks since it enables division of labour and specialization.

Further, co-management systems are believed to reduce transaction costs, they are open for the possibility of risk sharing and, finally, they enhance the establishment of conflict resolution mechanisms. Transaction costs are in accordance with North's definition (1997, p. 149) the costs associated to the exchange situation. Even though transaction costs might increase at the initiation of a co-management process (e.g. due to pending conflicts), they are likely to decrease over time, as a consequence of the repeated interactions. Concerning risk sharing, systems that are solely dependent upon one administrative unit are presumably more vulnerable to disturbances than systems of co-management. This argument can be compared to the discussion about resilience and robustness, which refers to a system's ability to absorb external disturbances, and/or its ability to adapt to these without changing the essential functions of the system (Holling 1986; Janssen, Anderies, and Ostrom 2007).

Finally, co-management is believed to enhance the capacity to develop appropriate conflict resolution mechanisms between the different stakeholders involved. Communicating and negotiating within an institutional framework increase the likelihood of reaching common agreements that promote collective action. As a result, the covenanting capacities of the system are improved (Ostrom 1992).

These theoretical assumptions about the central qualities of co-management systems are supported by many empirical studies. Without explicitly discussing co-management, Lansing and Miller demonstrate how co-management networks of Balinese irrigation systems coordinate the activities of different units and, thus, contribute to the sustainability of local rice farming and related livelihoods. Although lacking formal coordination, a number of so-called *water temples* fulfil the role of facilitating coordination between the different branches of this extensive irrigation system (Lansing 1991; Lansing and Miller 2006). Further, in an extensive study of the Kuhls (i.e., irrigation systems in the North Indian Kangra Valley), Baker (2005) analyzed how and with what means co-management networks contributes to sustainability. 'In the Kuhls of Kangra, we see the potential of networks in enhancing the resilience of common property regimes and thereby facilitating their ability to endure, especially under conditions of environmental risk and uncertainty' (Baker 2005, p.208). The system is sustained both by the physical construction that enables such acts as water sharing, but also by a sense of community that is established.

Yet other examples are provided in a dissertation by Bodin (2006). The study is comprised of case studies from Kenya and Madagascar, in conjunction with a set of computerized studies, all of which tell a similar story. Co-management networks matter and their configurations are intimately associated with the performance of social-ecological systems. For instance, certain structural properties are found to affect the spread and sharing of ecological knowledge within a community of users (Crona and Bodin 2006). Thus, not only the existence of networks, but also how they are configured, may matter. What do we mean by structure in this respect, and how are these qualities related to social relationships?

3. The network structure of social capital

The 'network approach', within policy analysis, has a focus on problem-solving structures, constituted by the involved actors and their relationships. These structures can be referred to as policy networks, i.e. 'problem-specific entities, organizing a policy area by different forms of collective action' (Carlsson 2000, p. 508). This approach is comparable with perceptions of co-management as governance structures, discussed in the previous section. However, the objective here is not merely to emphasize the importance of networks, but to outline in what respect they are important. In order to do so, and to fulfil the purpose of presenting an analytical framework for network studies of co-management, there is a need to outline why, and how, network structure can be assumed to matter in organizing and performance.

The evolution of a policy network, and presumably also of co-management networks, can be regarded an outcome of purposive action taken by self-interested individuals. This does not mean that accidental behaviour or unintended effects would not matter. But in general, actions emanate from the urge to maintain or procure resources of various kinds; such as money, information, knowledge or legitimacy (Hanf and Scharpf 1978, p. 353f) Thus, networking is a matter of resource exchange; i.e. 'a series of interactions between two (or more) actors in which a transaction of resources takes place' (Lin 2001, p. 143).

Networking activities are often discussed in terms of bargaining games (Thatcher 1998; Elmore 1997). Due to the state of resource dependency, the actors need to negotiate and adapt to the strategies of others. Similar ideas are conveyed by Hanf and Scharpf (1978) and, also, by Coleman (1990, p. 134ff), who describes social action as a negotiating process in which actors, constrained by their existing resources and driven to maximize their interests, interact. Accordingly, these are the activities that, over generations, have been conducted in various resource management settings; for example, in the Balinese water temples, among the Kuhls of Kangra, or in fishing communities in Kenya.

The institutional performance of these systems is highly dependent upon how such bargaining interactions proceed. Granovetter (1985, 1992) has convincingly supported this stance in his argument about embeddedness. He offers an approach

to social phenomena, avoiding both the 'under and over-socialized' views represented by neo-classical economics and sociology, respectively. These two views have been criticized, partly because of their one-sided emphasis on either action or culture (structure), and partly because they share a 'conception of action as uninfluenced by people's existing social relations' (Granovetter 1992, p. 6). A proper analytic framework should instead combine elements of methodological individualism, assuming the bounded rationality of self-interested actors, by means of a structural approach, and acknowledging that all actions are socially situated. A network perspective responds to this requirement.

The ideas proposed by the new institutionalism are consistent with the arguments above, and contributes to the theoretical argument why networks would matter (Peters 1997; Bogason 2000; Koelbe 1995; Marsh and Smith 2000; Marsh and Smith 2001; Evans 2001; Raab 2001). Policy networks might, in fact, be perceived as 'organized entities that reflect specific types of institutional arrangements' (Carlsson 2000, p. 58). They possess potential capacities to form institutional norms and rules, all of which structure the behaviour of the participating individuals. With reference to the examples provided by Baker and Lansing, it can be noted that networks evolve differently in different contexts, because they are the result of purposeful action among actors who try to deal with circumstances that are embedded in a local context. The rise, substance and structure of these networks affect, and are affected by, the specific institutional arrangements that evolve in accordance to the given problem and specific context, which in turn result in various performance. Accordingly, the institutional capacities of policy networks, and the assumed effect that network structure has on this process, verify the relevance of an analytical framework explicating the relation between network structure and institutional performance.

Hence, network structure is assumed to affect institutional arrangements and the characteristics of the policy process. Within the interdisciplinary field of social network analysis, the relational properties of the social world have long been recognized (Scott 2000; Wasserman and Faust 1994). Social network analysis also offers valuable tools for mapping and analysing social structures. Proponents for social network theory state that information about the network structure, i.e. 'how the direct relations are combined or arranged in a network' (Friedkin 1981, p. 41), provides information about the underlying structure of more stable interactions (Mizruchi 1994). The structure is thought to impose both constraints and opportunities for action. 'The structure of relations among actors and the location of individual actors in the network have important behavioural, perceptual, and attitudinal consequences both for the individual units and for the system as a whole' (Knoke 1990, p. 9). The pattern of relations either enhances or restricts the process of resource allocation and influence performance. Accordingly, important information about social interaction can be revealed by the structural qualities of the networks and, therefore, network structure can be treated as important independent variables that explain performance and outcomes.

3.1. Heterogenic and centrally integrated networks

The stance that relational aspects affect resource allocation actually is the basic implication of the concepts of social capital. Social capital theory has many faces and the concept has been ascribed many meanings and has been applied to a wide range of social phenomena, on different analytical levels. In political science, social capital is associated foremost with Putnam's seminal work (1992; 2000). Through his work the ideas related to social capital also reached a wider audience.

While human capital is an individual asset, social capital is found in the relations connecting individuals (Coleman 1990, p. 304). In spite of the wide range of applications, there basically are two elements that unite all lines of research addressing social capital. First, social capital is perceived 'as a metaphor about advantage' (Burt 2000, p. 346f). Using the words of Coleman, 'social capital is productive, making possible the achievement of certain ends that would not be attainable in its absence' (Coleman 1990, p. 302). Second, this advantage is assumed to spring out of the social structure: 'People who do better are somehow better connected' (Burt 2000, p. 347).

Thus, the definitions of social capital encompass two main aspects, relationships (or networks) and resources. Different researchers have handled the two ingredients of social capital differently. For some researchers (Lin, Fu, and Hsung, in Lin et al. 2001) the embedded resources are emphasized. Others, for example Burt (2000, 1997), focus on the networking aspects of social capital, indicating that network structure is a key element when identifying social capital. It is assumed that certain network configurations provide better resources; and, in accordance with this, networks are perceived as indicators of social capital. This latter standpoint, focusing on the relational aspects of social capital, is compatible with the central argument of this paper.

Burt (2000) has published extensive work compiling empirical studies, from various disciplines, that explicitly adopt a network approach on social capital. He identifies tremendous variety, but he has also noted that there primarily are two divergent ideas about the assumed relationship between network structure and social capital, namely the concepts of network closure and structural holes.

The *first*, network closure, is associated with Coleman's notion that well-connected networks foster social capital. It is assumed that these networks enhance communication, favour collaboration and restrain opportunistic behaviour (Coleman 1990, p. 306ff; Burt 2000, 351f; Lin 2001, p. 27). Accordingly, networks with many and strong connections in between, either directly or indirectly, are considered rich in social capital. Related to social network analysis, network closure might be indicated by two social network measures, namely the degree of density and centralization, respectively (Burt 2000, p. 373ff). Density is calculated by dividing the actual number of connections present within a network with the maximum number of connections possible (Scott 2000, p. 71). The degree of

centralization measure to what extent these interactions are centralized, i.e. how hierarchical the structure is (Scott 2000, p. 89ff; Wasserman and Faust 1994). The higher levels of density and centralization (later also referred to as centralized integration) the higher level of closure is assumed. However, as already mentioned, the literature shows a variety of different ways to measure the network property empirically. Since the purpose of this paper is essentially conceptual, the validity of different empirical measures will not be discussed any further.

Whereas the closure argument draws attention to the significance of accurate information channels within a group, the second, the structural hole argument, is more concerned with the importance of information diffusion between actors and between different sets of actors. These ideas can be ascribed to Burt, but truly draw on previous work; for example, Granovetter's (1973) often-quoted article *The Strengths of Weak Ties*. A structural hole is defined as the absence of connections within a network, or the presence of weaker connections. Individuals who are able to bridge such holes in the social structure are assumed to gain strategic advantages because they gain access to new and more diversified sets of information. Networks that are comprised of such individuals are considered rich in social capital, rich in opportunities and therefore, better performing. Burt labels them 'entrepreneurial networks' (Burt in Lin et al. 2001, p. 36). On the same theme, Lin (2001, p. 47ff) states that heterophilous interactions (i.e., exchange among actors with dissimilar resources) require greater effort, but also yield higher returns for the investors. Recall the earlier comment that transaction costs might be high at the initiation of a co-management arrangement, but are found to decrease over time.

The ideas underpinning the closure and structural hole arguments are, in a way, contradictory. However, Burt suggests a synthesis of the two. 'While brokerage across structural holes seems to be the source of added value, closure can be critical to realizing the value buried in the structural hole' (Burt 2000, p. 398). This view can be better understood by separating the local structure (i.e., the in-group relations) from the global structure (i.e., how the network is connected to other network constellations). In short, a network rich in social capital span many global structural holes, thereby reaching out to many diversified network constellations. At the same time, it has a local structure that is closely interconnected, facilitating the achievement of collective action. Thus, the two network features enforce one another in the process of resource allocation.

Depending upon the analytical unit in focus, structural holes can be identified by the use of various social network analysis measures. When it comes to policy networks, it might be hard to capture the weak ties that reach out to other network constellations, since almost by definition such networks consist of stronger ties, i.e., repeated and stable interaction. To overcome this problem, the diversity of actors, i.e. network heterogeneity, has successfully been used as an empirical measure and a proxy for the existence of linkages to other network constellations

(Reagans and Zuckerman 2001; Sandström 2004). The discussion about heterogeneity and homogeneity among resource users is of course more complex and might as well be understood as attributes of a community. In this article however, network heterogeneity refers to the 'diversity of actors' but the measure is assumed to reflect disparity in a more qualitative sense, e.g., that actors have different resources, values and backgrounds. Therefore, attribute data about involved actors can be used as indicators of heterogeneity; the more heterogeneous set of actors, the more the network is assumed to span, or bridge, global structural holes.

In his important study, Krishna (2002) tried to trace the roots of social capital, investigating economic development in 69 Indian villages. The study supports the idea that management systems, fostering development, likely benefit from heterogeneity, in the sense that the involvement of different types of actors makes it more possible for the system to access resources outside the local context. Thus, a dense and homogenous network alone is not accountable for performance, while bridging is a way of realizing its 'propensity for collective action' (Krishna 2002, p. 70).

Krishna's observations about the importance of network structure of social capital have been verified by other researchers as well, also among those who have been using social network analysis. For example, Provan and Milward's (1995) study on implementation structures in community health systems in the US showed that centrally-integrated networks (in-group closure) were more efficient. Reagan's and Zuckerman's (2001) study of the performance of R & D teams, on the other hand, confirmed the idea proposed by Krishna, namely the importance of network diversity; i.e. constellations that span holes in the global structure. Other scholars have argued that the task to be performed, e.g., its complexity, affects the way structure affects performance. There are many studies, ranging back to the Bavelas-Leavitt experiments in the late 40's and 50's, that confirms this, for example that the positive effects of centralization decrease as the level of complexity increase (Borgatti 1997; Brown and Miller 2000).

While bringing this section to a conclusion it should be emphasized that network structure also can be related to various functions in the very process of organizing. In a comparative case study of implementation networks within the sector of higher education the hypothesis about the relation between heterogeneity, closure and performance, brought forward by Burt was confirmed (Sandström 2004). With a bottom-up approach networks were mapped inductively and analyzed regarding their structural qualities, organizing capacities and performance. Drawing upon previous implementation research (Carlsson 1996; Hjern and Porter 1997; Hull and Hjern 1987) the question about what closure really enables and why bridging matters was addressed. As became obvious in the study, organization success is likely to be dependent on the performance of different so-called 'organizing functions', namely, problem-definition, resource mobilization,

prioritizing and evaluation, and the coordination of these. Presumably, all types of organization, the management of natural resources included, require that involved actors agree as to what the 'problem' to be addressed is. Given that numerous alternative ways of solving a specific problem exist, prioritizing is essential. In order to devise solutions to identified problems or challenges, resources are needed and must be mobilized. Also, the mobilization of resources is an intricate activity that must be organized, and part of this organization is dependent upon some internal perceptions of performance; i.e., evaluation or follow-up. Sandström (2004) suggests that the function of prioritizing, so vital for the process of organizing to proceed, is facilitated within centrally-integrated networks. On the other hand, the function of resource mobilization is facilitated within heterogenic networks that span global structural holes.

As already mentioned, attempts to apply the ideas and tools of social network analysis to study natural resource management systems have been rare. However, without explicitly discussing the logic of organizing or the structure of co-management, Bodin's (2006) findings support most of the arguments above. Bodin and his colleagues have conducted a set of studies that aimed to apply 'a network perspective on ecosystems, societies, and natural resources management.' Bodin concludes that the level of network density might bring disparate consequences for a system. On the one hand, it may enhance resilience and the adaptive capacity of a system since it reduces vulnerability and facilitate the exchange process. On the other hand, too high density might in fact 'contribute to a homogenization of the system […] which would reduce the systems ability to cope with changes, disturbances and surprises…' (Bodin 2006, p. 26).

This article is not about social networks in general but about network governance of natural resources. In the subsequent section, the theoretical work and empirical observations that have been discussed so far will be applied to the phenomenon of co-management. What kind of structural features are likely to facilitate well-performing co-management systems?

4. The structural features of co-management systems

Co-management is assumed to facilitate task allocation and resource exchange. It may reduce transaction costs and risk, and, finally promote the evolvement of mechanisms for conflicts resolution. In this section these functions will be related to the different network qualities viz. heterogeneity, density and centralization. What would a well-performing co-management network look like? But, before answering this question one might ask how a real-life co-management network might be configured.

Figure 1 depicts how a community of resource users is connected to a multitude of actors outside the organizational boundary of the community itself. The State and its various units are illustrated at right in the figure. In the centre, one finds the community and management tasks (A–F) that presumably must be con-

ducted. As can be seen, the web of relationships is fairly rich and spans over organisational boundaries, even to other geographical areas. It also should be apparent that the traditional divide between what is regarded as private and public is blurred (cf. Geisler and Daneker 2000). Obviously, the network spans a number of global structural holes, thus indicating a certain degree of heterogeneity.

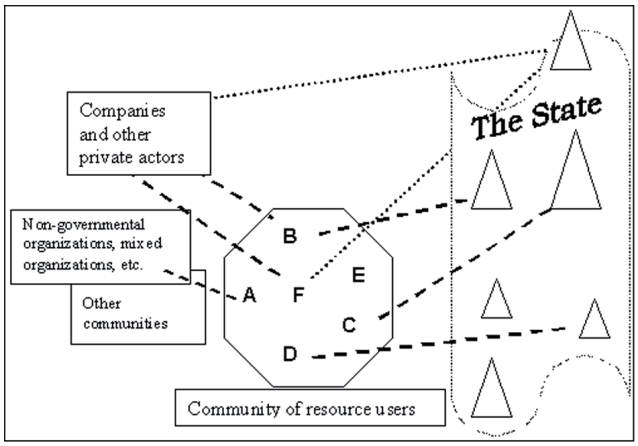

Figure 1: Example of a co-management network. The figure is based on the pattern of collaboration that has been elucidated within the community-managed forests in Sweden (Source: Carlsson 2003; Carlsson and Berkes 2005).

Network heterogeneity has in various studies been proven related to the function of resource mobilization and performance, in terms of innovation (Reagan and Zuckerman 2001; Sandström 2004; Bodin and Norberg 2005). The literature on the importance of cross-scale linkages can be perceived as elaborate support of the benefits of heterogenic networks, and arrangements that integrate actors from different sectors and different levels of society. Applied to the discussion about well-performing co-management systems, the hypothesis would be that heterogenic networks facilitate a system's ability to access and exchange resources. Therefore, it could be proposed that well-performing co-management systems are heterogenic networks that have a tendency to cross organizational boundaries. Whether the network in Figure 1 is regarded to be dense, whether some actors have a more central position, or whether some relationships are stronger than others cannot be determined from Figure 1.

Figure 2 illustrates how input data for social networks normally are represented, in particular as a matrix of relationships. For the purpose of the discussion, Figure 2 is a so-called un-weighted matrix, only indicating the existence of a particular relationship, not, for instance, their content or strengths.

	Actor 1	Actor 2	Actor 3	Actor 4	Actor 5
Community A	•		•	•	
Community B		•			
Community C					•
Community D		•			
Community E	•	•			

Figure 2: Example of a matrix of relationships among five communities and six external actors.

As illustrated in Figure 2, five different communities have some kind of relationship with five external actors. These actors might be NGOs, state authorities, public foundations, scientific organizations, companies. For example, Community A has relationships with Actors #1, 3 and 4; while Community C has a relationship with Actor #5 only. If Figure 2 would have been filled with many 'dots', and if the relationships would have exhibited significant strength (e.g. strong and repeated interactions), we would conclude that the network in question is densely connected. Further, if one actor could be distinguished as being significantly more connected than others, the network would be characterized as centralized (and with a high level of in-group closure). Here, however, our mission is to discuss the logic of heterogeneity and, for this purpose, it can be assumed that the relationships represent management agreements; for example, that Actor #5 performs monitoring tasks on behalf of Community C, while Actor #2 serves three different communities, and so forth. Given that the external actors represent different groups, levels of competence, skills, and interests, this network definitely spans a number of structural holes. And, in the best of all worlds, these differences will increase the quality of management. This type of heterogeneity can be understood as first-order heterogeneity, but there also is something that we can call second-order heterogeneity, which is traceable in Figure 2.

Following the methods of social network analysis, it is possible to generate two more matrices from the information provided in Figure 2. Thus, it can be concluded that Actors #1, 3 and 4 are connected, because they serve the same community. Consequently, it is possible to conclude that Community A has 'created' a network among external actors that are not elsewhere connected! The same logic can be applied to the communities; for example, Communities B, D and E can be said to be connected, because they share the benefits of having access to the same competence (actor).

The empirical reality behind these stylized relationships is easy to comprehend. For example, it is likely that NGOs or academic units that serve the same village have reasons to meet, discuss, and compare their experiences. The same goes for communities that utilize services from the same external actors. This type of 'indirect coordination' (c.f. Lindblom 1965) has not been elaborated in co-management research, something that social network analysis enables. Here,

we call this phenomenon second-order heterogeneity, because it is to be regarded as a by-product of management systems that have a multi-actor character.

How are these observations about heterogeneity related to the other salient feature of networks, viz. density and centralization? We have learnt that network integration is related to the ability to achieve collective action (Coleman 1990). Integration also is connected to the earlier-mentioned organizing functions of prioritizing and effectiveness (Provan and Milward 1995; Sandström 2004). Applied to co-management, the hypothesis would be that this network feature affects the internal activity within the network, in a way that reduces transaction costs and fosters a system's ability to make decisions and solve conflicts between different stakeholders. Thus, the hypothesis would be that well-performing co-management systems are comprised of networks characterized by a heterogeneous set of actors and that they, at the same time, are centrally and densely integrated. In Figure 3, the hypotheses generated in this paper are summarized.

Network Heterogeneity	Low — **Network Density and Centralization**	High
High	In these kinds of networks, access to, and exchange of, resources are improved. However, high transaction costs and difficulties in making priorities and managing conflicts between different interests hamper the policy process.	High levels of heterogeneity promote the access and exchange of resources. At the same time, high levels of density and centralization improves the internal decision making process by lowering transaction costs and fostering good conflict resolution mechanisms.
Low	This kind of network suffers from scarce resources and has obvious difficulties in establishing collective action.	The ability to make decisions and solve conflicts at low transaction costs is possible within this network. However, the process of resource mobilization is insufficient, which affects the ability to find innovative solutions.

Figure 3: The relation between network structure and qualities of co-management systems.

Resilience is a key concept in the discussion about sustainable natural resources management. Paradoxically, a management system needs both to resist losing its structure and to react and adapt to disturbances in the external environment.

Bodin and Norberg (2005) concluded that 'too much connectivity and too little autonomy among management units reduces variation in knowledge, which is crucial in managing complex systems' (p. 188). If co-management systems are too dense; they are more vulnerable to external stress and less innovative. Cross-scale networks, with a heterogeneous set of actors, thus are less vulnerable to negative disturbances. They are more likely to possess the proper resources, like for example, ecological knowledge, to know when to react and adapt. On the other hand, if they are too heterogeneous, and less integrated, it is more difficult to prioritize and make joint decisions. The more closely connected a group of actors is the more stable the network will be. Additionally, in order to react and to achieve institutional change, a high level of integration is necessary. Thus, resilience obviously is highly affected by both structural properties.

Applied to, for example, fish resource management one would conjecture that co-management networks, situated in the right column in Figure 3, with a lot of communication channels between different stakeholders, and with a clear coordinating actor, are more efficient in the sense of taking necessary decisions. This type of management also is likely to promote the development of appropriate conflict resolution mechanisms. In other words, there is a functioning arena where rules-in-use regulating the provision and appropriation of the resource could be developed and maintained. At the same time, resilience is likely to be improved if a variety of different stakeholders are represented in the decision making structure. For example, the input from scientific expertise may contribute systematic observations and information about relevant research. The involvement of local users, on the other hand, will provide the process with local ecological knowledge and ensure the legitimacy of the decisions made. In this type of co-management, linkages connecting local, regional and/or central government authorities are presumably established. These cross-scale linkages, improve the quality of the process.

To test the validity of this description, a research agenda, enabling these kinds of empirical studies, using social network analysis, is encouraged. While there is a need for more empirical investigations, there are also a number of theoretical issues to consider. For example, how is network size related to performance? What kinds of boundaries are important to bridge? Does network centralization affect innovativeness? How densely connected should an effective network be? The issue concerning a trade-off between heterogeneity and integration has previously been addressed by for example Bodin, Crona and Ernstson (2000). This challenge is conceptualized in Figure 4.

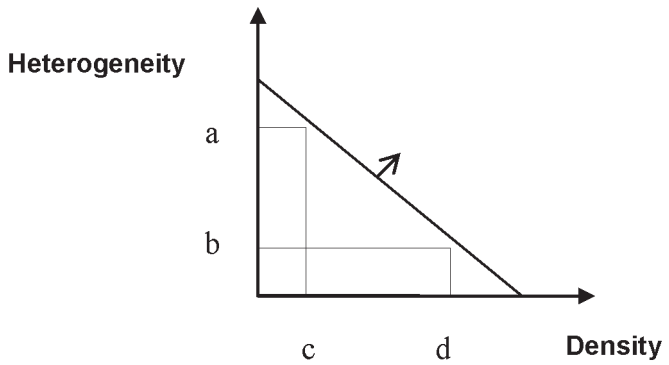

Figure 4: Trade-off between density and heterogeneity in co-management systems.

Presumably, all co-management networks can be described in terms of a mixture, and a trade-off, between heterogeneity and density. Thus, system a-c, in Figure 4, is characterized by a high level of heterogeneity and a low level of density, whereas system b-d has the opposite qualities. Whether there is any 'best' mixture in this regard really is unknown. Intuitively, one might think that increasing one of the features automatically would reduce the other; but, to our knowledge, this has not yet been demonstrated empirically. It may be that we must accept the indicated 'seesaw principle'; the only remaining alternative is to shift the line to the right in Figure 4. How might this be done in real-world settings?

5. Conclusion

If the assumed relationship between structure and performance is taken seriously, obvious questions would be: How should such networks be established? And, conversely, do they just evolve? From a state-centred perspective on governance, the role of the state in establishing such networks is especially interesting to acknowledge. Is it possible for the state to affect the establishment of these successful networks; and, if so, how? How public actors may apply a network perspective, as a means to improve policy making, has been discussed thoroughly by Kickert, Klijn, and Koppenjan (1999). They argue that, due to a unique possession of resources (such as legislation power, budgets, personnel, access to mass media, and democratic legitimacy), governmental actors have considerable power to affect governance processes. An empirical analysis by Schneider et al. (2003) shows how a federal policy program, such as the National Estuary Program, can have a direct effect on the establishment of boundary-spanning policy networks. These findings indicate that government might, in fact, facilitate the establishment of certain network constellations. The challenge for the state is how to adapt to this new role of being a partner that tries to find ways of influencing the existing governance structures or fostering the creation of new ones.

Thus, adopting a network perspective on governance does not necessary eliminate involvement of the state. As a matter of fact, the state, or the different 'faces' of the state, might be important actors in the policy process. This is also discussed in the previously-mentioned work by Baker (2005) and, following his approach, one can conclude that the actual relevance of particular actors, such as the State, needs to be subjected to empirical investigation and not taken for granted. Further, the adoption of a network perspective on co-management does not mean that the power within governance structures is equally distributed. A common misconception about networks is the assumption of a non-hierarchical structure. In many publications, the non-hierarchical quality of policy networks has been emphasized. However, in most of these publications, the objective has been to contrast the entities with formal political-administrative hierarchy, not to discuss their structural features.

In fact, policy networks often are hierarchical due to the asymmetric state of resource dependency, but this power distribution does not necessary reflect the formal hierarchy. Actors, resources, and power distribution are subjected to constant change within social networks. Therefore, it is important to regard co-management networks as evolving institutional arrangements, and not as fixed entities that can be inherited, like State hierarchies. Thus, in order to better understand contemporary systems for natural resources management, the dynamic of network evolvement and the relationship between structure and performance during different time phases (fulfilling different functions) must be addressed.

The aim of this article has been to provide an analytical framework for network study of co-management of natural resources. We have argued that the qualities of a well-performing system will be facilitated by certain network properties, particularly network heterogeneity and centralized integration. Accordingly, co-management networks that are heterogeneous, involving a diversity of actors, and that are centrally and densely-connected, are assumed to perform better than those not having these qualities.

We believe that applying a network perspective opens up a wide range of opportunities, which makes it possible to identify a number of important questions that need to be answered. By acknowledging the discussed structures as systems of governance, valuable knowledge about how to govern the commons might be achieved. In order to learn more about this, the structural effect of co-management networks governing the commons should thus be a concern for further empirical investigations. Studies examining the structural properties of successful and less-successful management systems would provide valuable knowledge regarding how structure affects performance. More case studies on natural resource management, comparing systems with divergent outcomes, potentially would be invaluable in developing theories regarding network structure of social capital and its implication for co-management.

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