A social network approach to analyze multi-stakeholders governance arrangement in water resources management: Three case studies from catchments in Burkina Faso, Tanzania and Zambia

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Given the cross-scale and multifunctional character of water, the decisions impacting on water involve a range of stakeholders related to each other through complex governance arrangements. Any transformation path towards more sustainable and equitable water use will need to work through these complex webs of social relations. There is however a lack of empirical research that addresses such multi-level water governance networks. This paper develops and applies social network analysis (SNA) to capture the cross-scale and multi-stakeholder governance networks in three catchments in Burkina Faso, Tanzania and Zambia. Using a questionnaire and semi-structured interviews, we traced relations between state agencies, NGO's, and villages. SNA has proven valuable for analyzing multi-stakeholder governance arrangements and to engage with the social complexity of water resources governance across multiple scales. We discuss analytical strategies and emergent results and how we intend to build comparative work with other catchments.

Key words: Social network analysis, multi-level governance, catchment management

1. Introduction

In the past, water resources management has often been characterized by a command and control approach that usually focused on well-defined problems and engineering solutions (Pahl-Wostl et al. 2007). However, top down management approaches executed by a central government agency usually do not lead to satisfactory outcomes (Ostrom 1990; Holling and Meffe 1995). Over the years different types of governance systems have been promoted as solutions and water policies have put varying emphasis on the state, markets or users groups to govern water (Meinzen-Dick 2007). Empirical evidence suggests that no single governance model works across all cases and at all scales (Ostrom et al. 2007).

Governing water usually requires collective action among many actors, since the action of one actor often influences others sharing the same resource (Rogers and Hall 2003). Furthermore, and equality important, information and resources needed for effective management are dispersed among different actors. Recognizing the importance of different management units interacting across multiple scale new frameworks for governing natural resources like water have emerged (Bodin and Norberg 2005). Polycentric institutional arrangements have been proposed to be better suited for governing social-ecological system (Ostrom 1998). Concepts such as co-management, adaptive co-management, and adaptive governance have been suggested as institutional responses to deal with the uncertainty and cross-scale interactions that are inherent in the governance of nature society interactions (Carlsson and Berkes 2005; Folke et al. 2005; Saglie 2006; Armitage et al. 2009). All these governance frameworks entail "an implicit assumption about the establishment of social networks" (Carlsson and Sandström 2008), i.e. a notion of network management or network governance. The cross-boundary linkages (i.e. networks) that form between the different organizational and institutional levels are central to bring together otherwise fragmented actors and to support governance processes (Webb and Bodin 2008)).

Social networks are important for the management and governance of natural resources like water because they can facilitate the exchange of knowledge and resources. Sometimes informal social networks can be even more important than the formal institutions that have been set up to manage a resource (Bodin and Crona 2009). However, not all networks are equal. The structural patterns of relations (i.e. network typology) can affect governance processes and outcomes (Ibid.).

Adaptive management, adaptive governance and other forms of polycentric institutional arrangements recognize the crucial role of cross-scale interactions and argue for tapping into or establishing boundary spanning social networks that can link otherwise disconnected actor groups across sectoral boundaries and across different spatial and administrative scales (Cash and Moser 1998; Folke et al. 2005; Carlsson and Sandström 2008; Ernstson et al. 2010). Figure 2 illustrates schematically how actors from different sectors and/or scales are tied together in the management and governance of shared natural resources such as for example a catchment area.

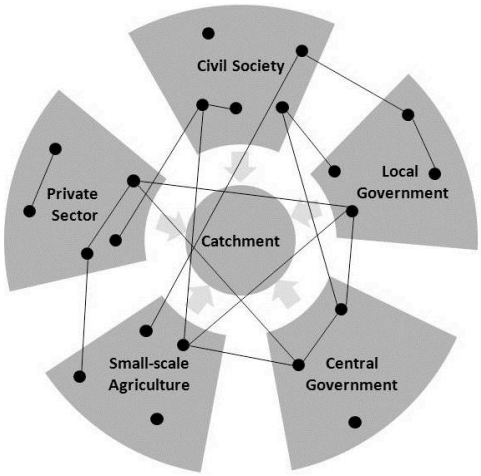

Figure 1 Cross-boundary interactions through social networks
Source: Adapted from Bodin and Crona 2009

Governance includes both the formal (codified and legally adopted) and informal (traditionally, locally agreed and non-codified) institutions and the various formal and informal interactions between state, civil society and the private sector (Rogers 2006). To study water governance thus implies to be ”concerned with those political, social and economic organizations and institutions (and their relationships), which are important for water development and management” (Rogers and Hall 2003). From a network perspective this would entail to map formal and informal interactions between the various actors influencing water resources management and governance (e.g. state agencies, community based organizations, NGOs, and private companies).

This paper aims to describe the application of a social network approach to studying formal and informal governance structures at three catchments in Sub-Saharan Africa. We describe how social network analysis, a well-established technique from sociology, can be used to empirically map out social networks between actors that influence water resources governance at the catchment scale (10-10.000 km^2). We then discuss analysis strategies and emergent results. We focus on two main research questions: (i) what is the existing social network structure based on collaborative relations in the case study areas? and (ii) given this description of the social network structure, how are water and related resources governed across spatial scales and levels of social organization?

2. Methods

Social networks consist of a set of nodes (individuals or collectives) linked through one or more relationships (Marin and Wellman 2010). Nodes and their links define network data and different links among the network members generate different networks. Social network analysis differs from other social sciences in the way that the focus is on the relations between actors and the potential effects of these relationships to explain the behaviour of individuals or the network as a whole through relational patterns (Marin and Wellman 2010). Social network analysis has developed useful definitions and algorithms to detect, describe and analyse complex social structures that emerge from the interactions of actors (Wasserman and Faust 1994). Many of the standard measurements in social network analysis, e.g. centrality or cohesive subgroups, are based on the numbers and length of pathways among actors (Hanneman and Riddle 2003). The number of links an actor has to others and the relative position of an actor within the relational space gives rise to potential opportunities and/or constraints for individual actors, or for sets of actors. Social network measures can be used to describe certain relational characteristics (or positions) of individual actors (e.g. centrality) or the structure of the whole network (e.g. size, connectedness). There are a row of measurements that can be made. A simple example would be the relative importance of a few actors that have many links, tying a network together and preventing it from being fragmented into many disconnected components (Webb and Bodin 2008). Such actors can be identified using measurements, e.g. centrality, developed

in the field of social network analysis. Previous studies in natural resource management can provide guidance on selecting important measurements (Bodin 2006; Crona and Bodin 2006; Ernstson et al. 2008; Prell et al. 2009; Bodin and Crona 2009; Sandström and Rova 2010; Schiffer et al. 2010).

The units of analysis in this study are social actors (organizations or groups) that influence water resources and the relationships among these actors. Since one of the strength of the network approach is the ability to move between micro and macro analysis, the level of analysis can be the individual actor, dyads of actors, group of actors, and the network as a whole. The organizing principle to decide which actors to include in this study was that the organizations (or its members) directly or indirectly influences the complex of water sources and flows in the particular catchment area. Direct influence means that an organization directly uses water or modifies water flows through one of the following activities; (i) modification of land/vegetation cover (e.g. planting of crops or grazing of animals); (ii) flow control measures (e.g. reservoirs to store water or channels to access water); (iii) water withdrawals and discharge (e.g. domestic use or industrial discharge) (cp Falkenmark 2003). Indirect influence basically means that an organization is not directly modifying land, water or vegetation but through its activities influences other actors that do so. For example a governmental organization providing funding for a new irrigation scheme therefore indirectly influencing water use and flows within the catchment.

The assessment has a spatially explicit focus on the actors active within the hydrologically defined boundaries of the catchments. However, the analysis cannot be confined to this single spatial scale since actors outside the catchment also influence how land, water and ecosystems are governed within the catchment area. The following statement by Merry and colleagues, (2007:219) illustrates the issue: “water governance, management, and use must be considered comprehensively, within a problem analysis context that looks at ‘problemsheds’ – the boundaries of a particular problem as defined by a network of issues – rather then as watersheds”. The study therefore focuses on the catchment scale, but also considers relevant factors and determinants from larger scales and how cross-scale interactions influence processes and outcomes at the local scale. Using a multi-scale approach, social processes can be assessed at the scale at which they operate and linked to processes at other scales and levels of social organizations (MA 2003). Figure 2 shows a stylized image of network structures and how, based on a better understanding of the existing social network structures (A), potential intervention points can be identified (A>B), to adapt the governance network (B).

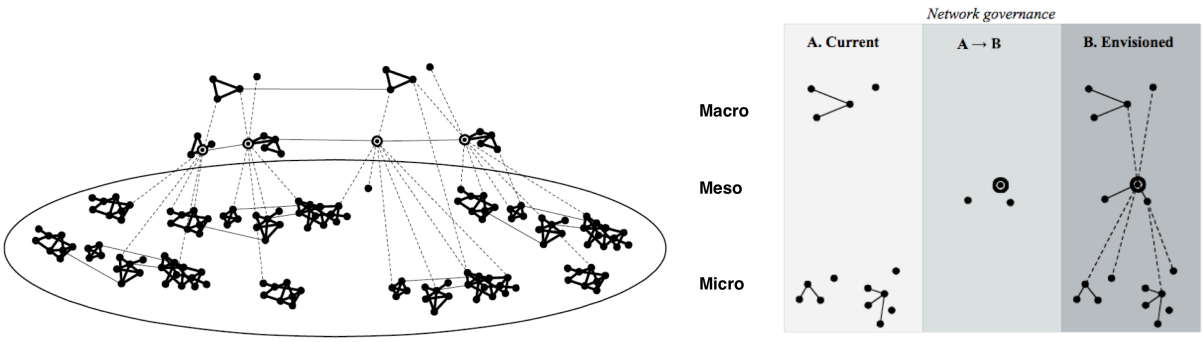

Figure 2 Stylized image of network structures at different scales
Source: Ernstson et al (2010)

The datasets from the three watersheds in Burkina Faso, Tanzania and Zambia were generated using a consistent methodology. Data was collected through a combination of quantitative and qualitative methods such as semi-structured interviews, group discussions, document analysis, personal observations and an organisational survey that contained questions to generate the social network data. To generate the social network data, respondents were presented with a recall list, that is a complete list of all the organizations identified during a pre-study, and asked to mark their relationships to other organizations. Respondents were asked to specify three relationships: (i) exchange of material resources; (ii) exchange of information; and (iii) collaboration with other organizations. The three relationships should be regular, long-term and concerning land, water or ecosystems management in the catchment area. In addition to the relationships of organizations, the survey generated data about organizational attributes, e.g. type of organization, activities influencing water sources and flows, upstream/downstream position of activities, scale of activities etc. Since each relation defines a different network, three sets of social network data were generated in each of the three watersheds. In the rest of the paper we will focus on collaborative relations only.

The data sets were analyzed using the software UCINET and NetDraw (Borgatti et al. 2002). The software makes it possible to (i) represent the relational data (adjacency matrices) as images that can be visually interpreted, and (ii) measure structural network properties at different levels of the network (from the actor, group, to the whole network level). The governance networks have been analyzed through a combination of social network measures, which are summarized in table 2. The interpretation of the measurements was also made through using qualitative data, which was generated through interviews, documents and observations. For a more detailed description of the various measurements and their application in the Tanzania case see Stein et al. (submitted).

Table 2. Network measurements

Level of analysis	Network measure	Definition
Actor or individual	Degree centrality	Measures an actors centrality according to the number of direct links to other actors (Degenne and Forsé 2004)
	Betweenness centrality	Measures the extent to which an actor lies between two other actors who are themselves disconnected (Wasserman and Faust 1994)
Network or subgroup	*Density*	*Ratio of the number of actual links to the number of possible links in the network (Monge and Contractor 2003)*
	Centralization	*Measures how variable or heterogeneous the actor centralities are (Wasserman and Faust 1994)*
	Cohesive subgroups	Subsets of actors among whom there are relative strong, direct, intense, frequent, or positive ties (Wasserman and Faust 1994).

3. Study areas

The three case study watersheds are the Nariarlé in Burkina Faso, the Mkindo in Tanzania and the Mwembeshi in Zambia (see figure 3). All data sets have a particular focus on the meso or catchment scale (10-10.000 km^2), but include actors from the local level (e.g. farmers groups, villages leaders and community based organizations) to the regional, national and international level (e.g. state agencies, NGO's and the commercial private sector). What follows is a short description of the three case study areas.

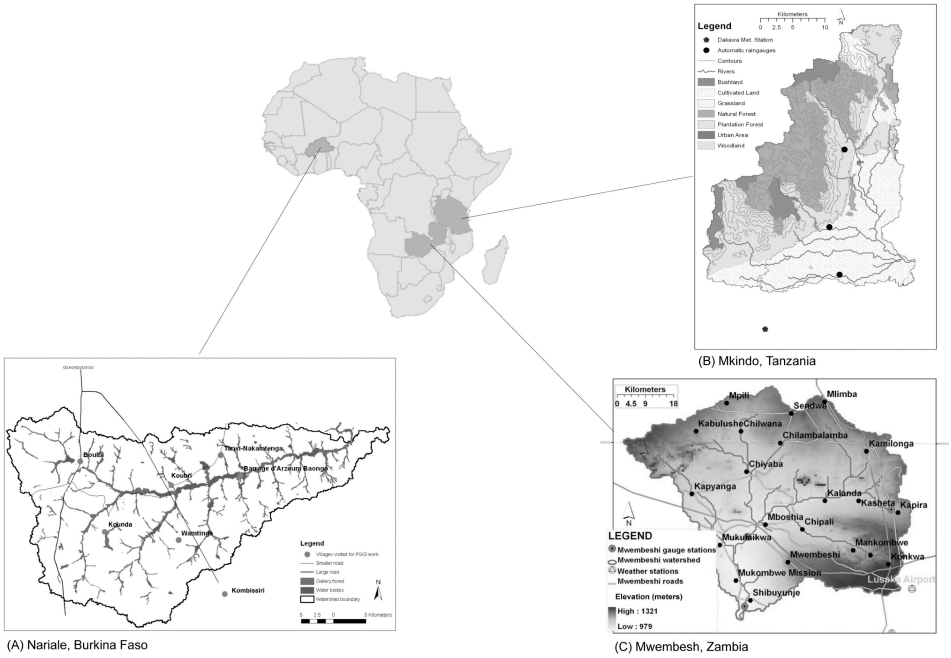

Figure 3. Location of case study areas. The three case studies are located in Western Africa in Burkina Faso, in Eastern Africa in Tanzania, and in Southern Africa in Zambia.

Nariale, Burkina Faso: The semi-arid watershed of Nariale is situated on the outskirts of Ouagadougou. The 1060km2 watershed contains several cascading small reservoirs, which feed small and larger scale (commercial) irrigation systems. The watershed has one of the highest concentrations of small-scale multi use reservoirs in Western Africa, but 60% of areas are under rainfed smallholder farming. Population density is high at 77 p/km^2 and water resources are limited, especially during the dry session.

Mkindo, Tanzania: The 913 km2 watershed ranges from humid to semi-arid rainfall regimes and contains a mountain forest rich in biodiversity. Multiple types of smallholder and commercial farmers practice diverse agricultural systems including rainfed cereal and tubers, pastoralist, irrigated paddy

rice and cash crops, small and large scale sugar cane plantations. Water resources are relatively abundant, but unevenly distributed in the watershed and water resources development is restricted by limited investment capacity and existing conflicts about land and water resources.

Mwembesh, Zambia: This sub-humid watershed is approximately 4118 km2 located at the outskirts of Lusaka. Despite the peri-urban location, some areas in the watershed have only marginal access to markets due to the lack of roads. Smallholder farming is pre-dominantly rainfed, for household consumption. Large commercial farms are located along the road using high tech irrigation and ground water sources. Water pollution and its use in agricultural production are a health concern.

4. Findings and discussion

The collaborative networks underpinning water governance in the three watersheds bring together a diverse set of actors from government authorities, civil society and the private sector that span from the community level to the international level. Figure 4 provides a visual representation of the networks of collaborative relations influencing water governance in the three catchments. The results illustrate that the institutional landscape influencing water governance is much more complex than suggested by formal policy. Below we highlights some of the patterns revealed through the social network analysis and discuss how they are important for understanding water governance dynamics.

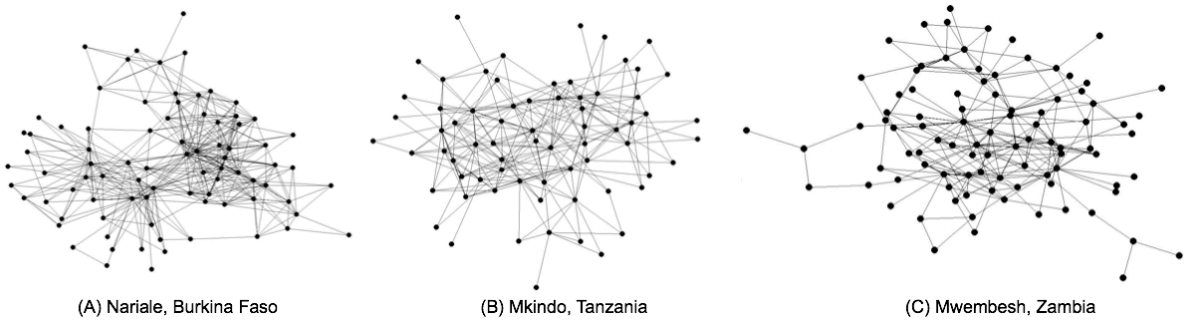

Figure 4. A visual representation of the networks of collaborative relations influencing water governance

What this study of water governance networks reveals is that numerous actors at the catchment scale who have no official mandate to manage water resources are nonetheless relevant in the governance system. Often community based organizations (CBOs) or other informal, i.e. non-codified institutional arrangements, emerge and perform important functions with regards to water management. However, the network analysis revealed that their activities are rather localized and seldom coordinated across the wider catchment. Community based self organized institutional arrangements are often located in the periphery of the network structure, meaning they have relatively few relationships to other actors, especially when they are located in other part of the catchment.

In all three cases it seems that there is currently no organization, formal or informal, that coordinates the various water related activities across the catchment scale, i.e. there are limited horizontal interactions that cover the wider catchment. Furthermore, preliminary results indicate that local actors directly influencing water sources and flow have limited linkages to official actors at higher-levels of governance, i.e. limited vertical interactions. However, in all three cases there are often a few key actors that hold the network together and prevent it from becoming fragmented. Figure 5 shows the same networks as figure 4 but node size is displayed as a function of betweennees centrality, meaning actors that connect otherwise disconnected actors are shown as bigger nodes.

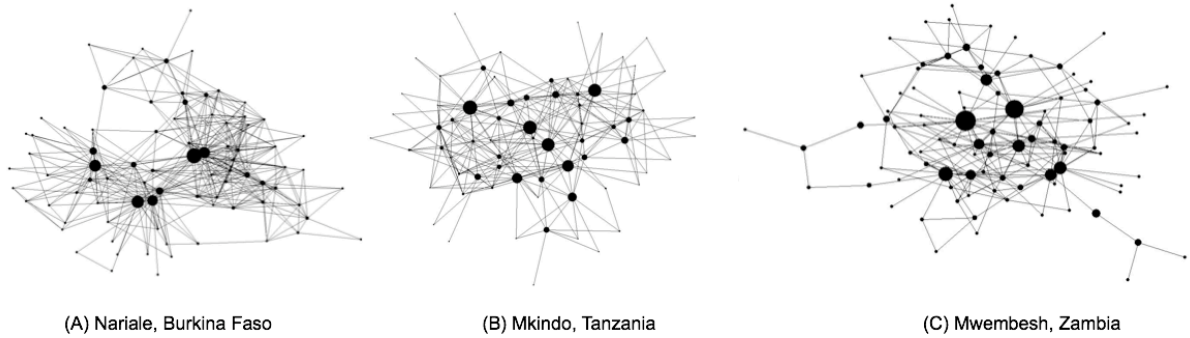

Figure 5. Networks of collaborative relations with node size based on based on betweenness centrality

In Burkina Faso two NGOs connect various organizations that have emerged around the numerous multi-use reservoirs in the catchment. In Tanzania the Village Chairperson and Village Executive Officer, are central actors in the network as they provide crucial links within their villages, but also to other villages and higher level of government. In Zambia on the other hand a similar coordinating function is performed by traditional authorities, the village headman and chiefs, which are important in many aspects pertaining natural resources management, especially the allocation of land and mitigation of conflicts.

In all three catchments, local government authorities, traditional authorities and local NGOs seem to be potentially influential for the governance of water. While these actors are not officially mandated to manage water resources, they nevertheless play a central role in everyday decision making of local resources users.

Our preliminary results seem to suggest that local resource users have their own, often informal, institutions for governing water resources and that these institutions operate in parallel to the existing formal institutions at higher levels. The lack of interaction between these two quite distinct governance systems can have the result that opportunities to improve water resources management are not realized.

Agent based modeling of different network typologies and empirical data both suggest that, at least up to a certain extent, connectivity facilitates joint action and enhances adaptive management (Bodin and Norberg 2005). Relationships can be especially valuable when they connect actors that have different knowledge about the system and could therefore complement each other, i.e. bridging ties. In the case studies presented here, farmers usually have very detailed knowledge about the state of water resources in the area where they farm. Governmental officials on the other hand may have information about long-term changes in the water system, e.g. predicted impacts from climate change. A network structure that allows for such information to flow in both ways could improve the monitoring and management of water resources. However, to realize such scale-dependent comparative advantages, cross-boundary interactions (i.e. networks) are necessary (Cash and Moser 2000; Ernstson et al. 2010).

This paper does not suggest networks as a new panacea or solution for water governance problems. Rather the network perspective outlined here should be seen as a means to move beyond the unproductive debate about state versus market and the role of communities that often characterizes discussion about water governance (cp Rogers and Hall 2003). Among scholars and practitioners alike, there is still a general preference for simple solution to complex governance problems (Ostrom 2007). But blue print solutions cannot work where adaptive management and governance is needed. The challenge is to find the right balance between different actors, (state, civil society and private sector) and to improve the effectiveness of the cross-scale interplay between these actor groups. Identifying and building on existing social structures seems to be a more promising approach then promoting a single governance system (e.g. state, markets or users groups) and applying it in all cases. Attempts to improve water use, management and/or governance could benefit from building upon already existing social structures, some of which have been revealed through the social network approach presented here.

5. Conclusions

This paper presented a social network approach as a way to describe and analyze complex governance arrangements that influence how water is used and managed in three catchments in Burkina Faso, Tanzania and Zambia. With the aid of social network analysis we have revealed some underlying patterns of how these networks are structured, helping to make visible not only the formal arrangements of water governance, but also those informal actors and their collaborative relations that could be of importance for watershed level governance. Using social network analysis, it was also possible to identify which actors play a more central role and which are more peripheral. Thus social network analysis has proven valuable for making existing social network structures transparent and for analyzing individual actors and the collaborative networks underpinning catchment scale governance.

Here we have only touched upon some the possible applications of social network analysis and it is important to keep in mind that what we presented here are just some preliminary results from our ongoing research. In forthcoming publication we will scrutinize the network data further using more advanced tools from the field of social network analysis. The empirical data from several cases will also offer the opportunity to investigate the intricate relationship between network structure and governance performance.

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