CONCEPTUALIZING HORIZONTAL COOPERATION IN REGIONAL SOCIO-ECOLOGICAL SYSTEMS THROUGH ACTOR NETWORKS AND COLLECTIVE ACTION: THE CASE OF THE BERG RIVER CATCHMENT

By
NADINE METHNER

DISSERTATION PRESENTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE DEPARTMENT OF ENVIRONMENTAL & GEOGRAPHICAL SCIENCE

UNIVERSITY OF CAPE TOWN
AUGUST 2014

Supervisors:
Dr. Gina Ziervogel
Prof Claudia Pahl-Wostl
Prof Ralph Hamann

PLAGIARISM DECLARATION

I know the meaning of plagiarism and declare that all of the work in the dissertation, save for that which is properly acknowledged, is my own.

Nadine Methner
14 August 2014, Heidelberg

DECLARATION OF FREE LICENSE

I hereby:

a. grant the University free license to reproduce the above thesis in whole or in part, for the purpose of research;

b. declare that:

(i) the above thesis is my own unaided work, both in conception and execution, and that apart from the normal guidance from my supervisors, I have received no assistance;

(ii) neither the substance nor any part of the thesis has been submitted in the past, or is being, or is to be submitted for a degree at this University or at any other University.

I am now presenting the thesis for examination for the Degree of PhD

Nadine Methner

14 August 2014, Heidelberg

ABSTRACT

This research investigates the role of horizontal cooperation in the adaptive management of regional socio-ecological systems (SESs). Horizontal cooperation refers to the collaborative, non-hierarchical interactions of actors across sectors, modes of governance and spatial scales. It can allow diverse actors to deal with the complexity and uncertainties that characterize SESs and to co-produce public benefits.

The research question is, *When does horizontal cooperation contribute to adaptive management in complex governance arrangements?* The Berg River catchment in South Africa serves as a case study to analyze such complex systems. The empirical focus is on the operational level which is responsible for maintaining key functions of the water resources in the SES.

A formal social network analysis is employed to describe and analyze the management of the Berg River catchment. The analysis focuses on (i) cohesion and (ii) heterogeneity, which are two network characteristics that affect learning and collective action in actor networks. Horizontal cooperation is further investigated by examining selected collective action initiatives with the help of Ostrom's eight design principles (1990). Constraints affecting collective action and the capacity to self-organize are identified, and the robustness of the governance arrangements arising from horizontal cooperation is evaluated.

The study finds that the behavior of actors towards each other and the SES is influenced by incentives provided by informal network structures, market mechanisms and bureaucratic hierarchies. Hence, modes of governance intersect at the operational level and consequently influence the nature of horizontal cooperation. While the quality of the management of the SES is largely determined by the patterns of interactions among the actors that manage the SES, these interactions are influenced by other institutional and organizational structures in which they are embedded. Unexpectedly, market mode incentives stimulate collective action in the Berg catchment and accentuate the need for addressing degrading water quality. Informal relations and emerging inter-organizational platforms matter for learning and for providing opportunities for collective action. Yet, the incentives (or lack thereof) created through hierarchical steering of the South African water governance system by the national government department are often counterproductive. That is, so far the self-organizing efforts at sub-catchment level could not be transformed into functioning governance arrangements because of constraints imposed by the hierarchical mode.

The study confirms that self-organization and collective action that arise from horizontal cooperation are important for the adaptive management of regional SESs. However, without being nested into larger structures and decision-making processes, they are insufficient for creating and sustaining

robust governance arrangements. Horizontal cooperation at the operational level can only be effective when supported by the hierarchical governance mode.

The thesis contributes to a growing field of interdisciplinary research on SESs, responding to the call for greater emphasis on relational patterns, governance, and environmental outcomes. It warns that horizontal cooperation cannot by itself guarantee adaptive management. Certain conditions are needed so that social and ecological outcomes are achieved and the cost of horizontal cooperation remains acceptable. A nested governance structure, in which horizontal cooperation is complemented by vertical integration is necessary for learning and collaboration within and beyond the operational level.

ACKNOWLEDGEMENTS

This thesis was a very long challenging, yet rewarding, journey that I would have never been able to complete without the help, encouragement, and support of so many wonderful and supporting people that have accompanied along the way; never given up me on me and my research.

I wish to thank all of YOU for your valuable inputs and recommendations to this piece of research and to my personal growth. You are my personal role models and heroes. While I cannot mention everyone in the limited space provided below there are several people that need special acknowledgement.

First off I would like to thank my wonderful supervisors, Gina Ziervogel, Claudia Pahl-Wostl and Ralph Hamann whose professional guidance and valuable support went far beyond the duties that is expected from a supervisor. I feel very fortunate to have had the honor to work with three outstanding scholars who have helped to shape the research presented in this thesis and who were my safety anchors in the interdisciplinary field of socio-ecological systems. Gina, my special thanks go to you. Thank you for all your encouragement and your tremendous support.

Judith Verma, Ramona and Ravi Liebhaber-Bagel, Geeske Scholz, Kathrin Knueppe, Bianca Tame, Sabine Stuart-Hill, Keith Forbes and Caroline van der Bers, I feel so blessed having such wonderful friends. You gave me so much strength. Thank you!

I also would like the Water Research Commission, the National Research Foundation and the Bode Foundation for the financial support of this PhD study.

Für meine Lieblingseltern!!!

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AM	Adaptive Management
AC	Adaptive Capacity
BEMF	Berg Estuary Management Forum
CMA	Catchment Management Agency
CPR	Common Pool Resources
CSIR	Council of Scientific & Industrial Research
CWDM	Cape Winelands District Municipality
DEA&DP	Department of Environmental Affairs and Development Planning
DoA	Department of Agriculture
DWA	The Department of Water Affairs
IB	Irrigation Board
RO	Regional Office
SALGA	South African local Government Association
SES	Socio-Ecological System
SNA	Social Network Analysis
SANBI	South African National Biodiversity Institute
WC	Western Cape
WCDM	West Coast District Municipality
WSA	Water Service Authority
WSP	Water Service Provider
WESSA	Wildlife and Environment Society of South Africa
WUA	Water User Association
WfW	Working for Water
WWF	World Wildlife Fund
WMOs	Water Management Organizations

1. Chapter: Introduction

"Water links the local to the regional, and brings together global questions of food security, public health, urbanization and energy. Addressing how we use and manage water resources is central to setting the world on a more sustainable and equitable path."

Ban Ki-moon, Secretary-General of the United Nations[1]

1.1. The Outset: a planet under pressure

Global climate change, an increasing population, urbanization, and aspirations for better living standards are a challenge to planetary sustainability. There is rising evidence that human actions have become the main driver for global environmental change and that the depletion of natural resources reduces the capacity of the planet to sustain our activities (Rockström et al., 2009). This raises serious concerns regarding our future and our aspirations to improve human well-being such as the achievement of the Millennium Development Goals. Bogardi et al. (2012:35) alert that "[t]he magnitudes of ongoing environmental transformations, including climate change, are signs of unsustainable socio-economic practice at global scale, raising the question how the planet will accommodate an additional three billion people by 2050." Even more unsettling is that those that are beginning to pay the costs of the wasteful use and unsustainable management of natural resources are the millions of people who have not been able to benefit from the prosperity created through current management practices.[2]

Considering that all life, human, terrestrial and aquatic, depends on water, water resources should be regarded as our most vital natural resources (Palmer, 2010). In particular, freshwater resources are essential for human life, economic development, and the functioning of the ecosystem services and goods. As the demand for drinking water and water for food and energy production increases, existing water resource systems are degrading at a pervasive rate. Until now human water security has to a large extent been achieved at the expense of freshwater biodiversity and the functioning of ecosystem services and goods that underpin human livelihoods (Vörösmarthy et al., 2010). For a long time, the water needs of ecosystems were ignored in policy and management practices. Whereas in recent years ecosystems have gained more acknowledgment as legitimate water users, the vital importance of ecosystems and biodiversity for sustainability and maintenance of freshwater

[1] (WWAP , 2012:v)

[2] It is estimated that over two billion people live still without sanitation and about one billion lack access to safe drinking water (Bogardi et al., 2012).

resources continues to be underestimated (WWAP, 2012; Palmer, 2010). As long as ecosystems and biodiversity are not seen as part of the solution to existing and projected water problems, and only treated as a casualty of them, the arbitrary and unfair competition between human and ecological needs for water will continue.

Water security is one of the most significant challenges of the 21st century and user conflicts, as both a cause and consequence, are on the rise. Yet, the perceived (primarily in water secure industrialized countries) and the experienced (primarily in developing countries) water crisis is not an issue of global water availability. As Pahl-Wostl et al., (2012:24) emphasize "[t]he most persistent challenges for dealing with the emerging water crisis lie in the realm of water governance, and many problems can be attributed to governance failures rather than the condition of the resource base itself". This becomes evident when looking at the amount of water that is being wasted, the unequal access to water across continents, but also within countries and regions. However, water is still seldom acknowledged as a cross-sectoral priority and a cross-cutting issue that demands coordination and cooperation among actors involved in the water-energy-food-land nexus[3].

This thesis sets out to make a contribution to the understanding of water governance, which here refers to the processes, actor constellations, and institutions that shape the decision-making and activities related to the use and management of water resources. Although the water governance challenge needs to be addressed at various levels, including the global, national, regional and local level (e.g., Gupta et al 2013), the attention in this thesis is directed at the regional[4] level of decision-making. Unpacking governance arrangements at this level is most appropriate for understanding how global drivers and local processes intersect and affect place-based management. To do so, this study describes and analyses the human dimension of water governance through the narrative of a small, yet economically important, South African catchment that is confronted with the degradation of its water resources through pollution and alien invasive vegetation. The thesis focuses on the joint management of the catchment's largest river, the Berg. By depicting the relations and behavior among the organizations that manage the catchment, and giving attention to the context in which these relations have been structured, this thesis advances a relational approach to better understand the governance of socio-ecological systems (SESs). Here, the emphasis is on processes considered necessary for social cooperation that extend beyond hierarchical structuring. The chief purpose of

[3] The water-energy-food-land nexus describes the intrinsic interdependencies and linkages that exist between water, food and energy security. Hence, achieving long-term security in one area can only be achieved in consideration of the other two (Ringler et al., 2013).

[4] The term regional is used in this study in reference to a spatial scale that is larger than the local level but smaller then the nation state.

this study is not necessarily to make generalizations from the findings of the examined case study. To a large extent processes and drivers that shape the governance in other regional SESs will differ. What the thesis does offer is an analytical and methodological design that can find application in the examination of management and governance processes in other regional SESs. In other words, this thesis presents a practical approach for the examination of complex governance arrangements in a particular setting. By doing so, the thesis provides important insights into the following: How to create and maintain robust governance systems that to a large extent have become structured around the collaboration of semi-autonomous actors which are not necessary compelled by formal obligation to contribute to the management of a specific SES. Robust governance systems are understood in this thesis as arrangements capable working satisfactory (i.e. efficient, equitable and sustainable water management) in light of changes or disturbances (van Laerhoven and Ostrom 2007; Hutjens et al., 2009; Mumby et al., 2014). Hence, they require balancing consistence with adaptability and transformability.

The rest of this chapter is organized in the following way: first, water management is introduced in the context of catchments, which are described in this study as regional SESs. This is followed by discussing the complexity of regional SESs and the complexity of the arrangements through which they are governed, an aspect of governance that is not well-understood. The subsequent section elaborates how this research gap is addressed in this thesis. The research aim and objectives are then presented, and the chapter concludes with an outline of the subsequent chapters.

1.2. The rising complexity of regional socio-ecological systems

Rivers are water resources whose management needs to be looked at in the context of the catchments in which they are embedded. Catchments can be understood as regional SESs which are defined as "a system which includes societal (human) and ecological (biophysical) subsystems in mutual interaction" (Gallopin, 2006: 294). Such systems are characterized by a high level of complexity, because of the wealth of interactions, non-linear processes and actors within the system (Gunderson and Holling, 2002; Berkes et al., 2003; Poteete, 2012). To illustrate further, catchments produce multiple ecological goods and services, of which many interact with one another and whose productions are non-linear. At the same time, various user groups (which possess different technologies, interests and decision-making power) who depend on specific ecological goods and services produced by the resource system, interact with and influence ecological processes through their practices at various locations within and beyond the catchment. Basurto et al. (2013) state that many problems that arise within SESs are often non-linear in nature, cross-scale in time and space, and characterized by an evolutionary character. Another defining characteristic of SESs is that they entail components that are self-organizing but also components that are designed. (Anderies et al.,

2004; Janssen et al., 2007). Humans design, for example, physical infrastructure and institutions with the aim of improving the performance of the system. The designed components in turn affect the functioning of the self-organizing social and ecological components. For a long time institutions and physical infrastructure were developed and implemented based on conventional, technocratic, command-and-control approaches ignoring important linkages and non-linear feedbacks that are critical for the functioning of regional SESs (Holling and Meffe, 1996; Berkes and Folke, 1998; Pahl-Wostl, 2007). This in turn has led to the degradation of many SESs because important system linkages were neglected or misunderstood.

Another factor that has increased complexity of SESs is that "the temporal and spatial scales of both human activity and our impacts on biophysical dynamics has fundamentally changed" (Anderies and Janssen, 2013:3). Regional SESs are no longer just shaped by the human activities *within* a regional SES or the dynamic interactions of localized ecosystem processes (Brondizio et al., 2009). Far reaching global processes, linked to economic globalization (e.g. market integration) and global environmental change (e.g. climate change), are now strongly affecting processes and decision-making in many regional SESs such as catchments (Young et al., 2006). Brondizio et al. (2009), for example, speak of increasing functional interdependencies; that is, the rise in socio-economic and biophysical linkages. In this context, Poteete (2012:135) emphasizes that "[f]ailure to recognize important components and processes limits understanding of these systems and is an important source of uncertainty about the responses to management practices and policies". This thesis therefore aims to reduce this uncertainty.

1.3. The need for adaptive management in regional socio-ecological systems

With the growing levels of interdependencies and associated rise in complexity and uncertainties as well as the many governance failures experienced in regional SESs, more adaptive and integrative approaches to the management of SESs have been advocated by both the scientific community and policy makers (Folke et al., 2005; MEA, 2005; Olsson et al., 2006). Management principles, such as Integrated Water Resources Management (IWRM) and international frameworks such as the EU Water Framework Directive, have been developed to integrate different types of knowledge, to account for biophysical boundaries of SESs, and to foster greater stakeholder participation (e.g., Jaspers 2003; GWP 2000; Kaika, 2003; EC, 2002). The intention behind these frameworks has been to consider important scales and levels[5] and to rectify misfits between the institutions that govern the

[5] While the terms scales and level are sometimes used interchangeably, scales are defined in this study in accordance to the conceptualisation provided by Gibson et al. (2000). The term scale expresses the different dimensions of a specific phenomenon and how these dimensions interact. More specifically, scale refers to "the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon".

SESs and the attributes of the ecological processes and functions of such systems (Kallis and Butler, 2001). However, in many industrialized and developing countries, legislative and organizational reform processes, aimed at transforming existing systems through which SESs are governed, have often not resulted in more adaptive and integrative management practices (Lundmark and Jonsson, 2014; Biswas, 2004; Medema et al., 2008; Horlemann, and Dombrowsky, 2012). That means, while formal rules may have changed, dominant actor relations and practices often have not.

This thesis argues that the unsatisfactory transition towards adaptive management practices can only be understood in the context of rising complexity of governance arrangements. Further, the rise in complexity has created considerable challenges for achieving the necessary coordination and cooperation amongst actors involved in the governance and management of SESs.

While governance is a contested term (see e.g, Kjaer, 2003; Robichau, 2011), in this study, it is understood as "a social function centered around steering human groups toward beneficial outcomes and away from mutual harmful outcomes" (Brondizio et al., 2009:256). It refers to the processes and structures through which formal and informal institutions are established and enforced, power is shared, and collective as well as individual behavior is shaped (Risse, 2011; Young, 2002). In democratic countries, governance is often concerned with the production of services for public benefit (e.g., collective goods and services such as public health, clean environment, public infrastructure, basic education or safety). While this has been the primary responsibility of governments, it is actually more appropriate to speak of the co-production[6] of services for public benefit as the role and contribution of non-state actors has increased. This is particularly the case in the area of environmental governance, where the production of services for public benefit strongly depends on the contribution and collaboration of non-state actors (e.g. Lemos and Agrawal, 2006). Because governance sets the conditions under which management has to function, management should be understood as an integral part of governance. In relation to SESs, management refers to specific activities through which the state of the SES, in particular the ecological processes upon which its functioning depends, is kept in a desirable bound (Pahl-Wostl, 2009). Water management functions include, for example, monitoring, pollution control, water allocation, financial, economic and information management.

Levels refer to locations along a scale "with lower levels being constrained by the processes taking place at larger levels" (Gibson et al., 2000: 218-219).

[6] In relation to public goods and services the term co-production has been introduced by E and V Ostrom (1977). See Aligica and Tarko (2013) or Alford (2014) for elaboration.

1.4. The increasing complexity of governance arrangements

By trying to account for cross-scale and cross-level linkages, and to create a better fit between administrative boundaries and ecosystem attributes, new approaches deployed for the management of SESs have contributed to the increasing complexity of the governance systems. Several studies in the realm of water management have shown, that problems of cooperation between newly established organizations at catchment scale and those organized at traditional administrative boundaries (e.g. spatial planning, local government) prove to be a barrier for implementing integrated management approaches (Herrfahrdt-Pähle, 2010; Pollard and du Toit, 2011). It has become evident that efforts to better fit the social system with that of the ecological system led to problems of interplay in the social system (Folke et al., 2007; Herrfahrdt-Pähle, 2010; Lebel et al., 2013). The rising complexity in governance arrangements and the necessity of cross-boundary collaboration has also been prompted by wicked societal problems[7] (Rittel and Weber, 1973) and claims for the democratization of decision-making processes (Berkes, 2010; Kjaer, 2011), including decentralization.[8]

As a consequence of these trends, private-public partnerships, community-based resource management and private governance arrangements have become an integral part of the governance landscape, supplementing bureaucratic hierarchical systems and policy making processes (Newell et al., 2012). Many of the arrangements do not follow a hierarchical structuring. Instead they have been associated with other modes of governance such as network or market structures (Rhodes, 1997), which follow a different internal logic for steering and coordinating social action (Pahl-Wostl, 2009).[9]

[7] The term wicked problems has its origin in the community planning field. It was coined by Rittel and Webber (1973), to describe societal problems that are so complex and incomprehensible that actors disagree how to define and solve them. Hence, such problems have multiple dimensions and numerous proposed solutions. They are also likely to lead to second order problems because of processes linkages and interactions across scales (Chapin III et al., 2008). Such problems need to be addressed through collaborative frameworks and the fostering of cross-boundary linkages in the governance system (ibid.).

[8] According to Larson and Soto (2008) and Berkes (2010) decentralisation (i.e. the shifting of responsibilities and authority to the lower levels of decision-making based on the principle of subsidiary) is mainly confined to the sphere of government itself and to the assignment of responsibility to lower levels within the government system. Devolution refers to shifting rights and responsibilities to local groups including local level government. For the purpose of the thesis devolution and decentralisation are combined under the term decentralisation which therefore captures downward and outward scaling processes in the governance landscape.

[9] Carlsson and Sandström (2008:35) for example indicate that networks can entail informal as well as formal (e.g. obligatory relations) patterns of interactions. They however caution that networks should not necessarily be

For example, networks have been more closely related to informal relations and institutions as well as self-organizing and emerging decision-making processes (Bodin and Crona, 2009; Duit and Galaz, 2008; Kickert et al., 1997). Market structures (e.g., supply-chain or agricultural value-chain relations) on the other hand, can be seen as a mode of governance that guides actions through demand-supply as well as buyer-seller relations (e.g. Lemos and Agrawal, 2006).[10] Kjaer (2011) points out that institutional arrangements of markets and networks do not displace traditional forms of governance. The three governance modes coexist and interact with each other and can create serious tensions amongst them. For example, network strategies may be at odds with formal hierarchical operating procedures (ibid). In these complex and intertwined governance arrangements the roles of actors have become blurred (Pahl-Wostl, 2009), and many actors have become embedded in institutional arrangements that often cross various levels, scales or different modes of governance.

It has become increasingly evident that in these complex multi-actor, multi-level and multi-mode governance arrangements, socio-economic activities can no longer be solely steered through hierarchical interactions. Consequently horizontal cooperation has gained in importance for societal cooperation and coordination. Horizontal cooperation is defined in this thesis as collaborative, non-hierarchical interactions of actors across sectors, modes of governance and spatial scales. However, based on the experiences with reform processes in many countries, it appears that currently many constraints to horizontal cooperation exist in complex governance arrangements. This has become particularly visible at the operational level.

The operational level is understood in this thesis as a functional level in a particular governance system (e.g. water governance) which in SESs is primarily concerned with maintaining the key functions of the SES and the implementation of existing policies. Hence, this level is mainly comprised of actors involved in the day-to-day management activities of the SES. In the past, the operational level involved a small stable set of actors (governmental technocrats and scientific experts). Nowadays it has shifted closer to the user level and to the resource base (e.g., the boundaries of the SES). Similarly, through decentralization and greater stakeholder involvement the operational level, in many countries the sphere of water governance has shifted closer to the local level. That is, stakeholders that have previously been users of rivers find themselves now also in the role of managers. This has led to a change in existing relationships among governmental technocrats,

equated with non-hierarchical structures. They highlight that many networks are indeed hierarchical due to the asymmetric power distribution within the network.

[10] Davies (2005) emphasises that each mode contains elements of the other and other authors have also emphasized that in most real world setting hybridized forms of those modes can be found.

local stakeholder groups, private sector entities and conservation agencies giving rise to new forms of collaboration and cooperation, alliance building but also confrontation.

Multiple factors exists that can inhibit the required cooperation and collaboration among those involved in the management of regional SESs. Collaboration among quasi-autonomous actors, for example, requires voluntary cooperation and cannot be imposed (Imperial, 2002). Tension may arise because different actors are embedded in different institutional arrangements and adhere to different sets of rules or incentive structures that cannot easily be reconciled. Most actors can be associated with particular stakeholder groups or sectors that represent specific interests and goals which in turn influences their commitment to the management of the SES and specific resources therein. Furthermore, actors may face different socio-economic and political pressures that can be linked to specific modes of governance in which they are engaged and which will constrain their willingness to engage in collaborative relationships that allow for joint management of the SES. For example, a farmer may face strong global market pressures (through the supply chain in which he is embedded) which propel him to intensify production or to change to a business model that neglects sustainable land and water management practices. Local government agencies that are accountable to local constituencies as well as state legislation find themselves confronted with resource constraints and heighten pressure for service delivery. They may, for example, opt for quick fixes at the expense of long term investment into skills and infrastructure related to water management. Conservation organizations, which depend on donor money and need to fulfill conservation targets, may find it difficult create partnerships with private landowners or government agencies that continue to dichotomize economic growth and environmental protection.

Several challenges, which have been associated with the decentralization processes themselves, can constrain the potential for horizontal cooperation among those involved in the management of regional SESs. Firstly, it has been noted that in many cases the transfer of responsibilities to lower levels of decision-making is often not companied by the required transfer of decision-making power and resource allocation to exercise those functions (Berkes, 2010; Larson and Soto, 2008). Secondly, without sufficient coordination or support from higher level authorities, decentralization can lead to fragmentation of management responsibilities. For example, some activities will be duplicated, whereas others important for the maintenance of ecosystem functions in SESs may just be neglected on the assumption that it is the responsibility of someone else (Pahl-Wostl et al., 2012). In addition, issues of accountability and transparency may arise (Larson and Soto, 2008; Agrawal and Ribot, 1999). For example, non-state actors that take on certain management functions may only be accountable to their own interest groups. They therefore, may be inclined to only advance the self-interest of the group they represent. Empirical studies have shown that in the decentralization process local elites

are often able to control functions and put forward their own interests without necessary considering the needs and interest of other less powerful stakeholders (Persha and Andersson, 2014; Palmer and Engel, 2007).

To summarize the preceding claim, two factors have contributed to the rise in complexity in governance arrangements; firstly the attempt to attune governance arrangements to the complexity and uncertainties that characterize SESs and secondly, the more general opening of the governance landscape, exemplified here through processes of decentralization. It has further been argued that while horizontal cooperation has gained in importance for social cooperation and coordination, many constraints to horizontal cooperation exist in complex governance arrangements. This has had considerable impact on the operational level in governance systems which until now is a point not well addressed by the scholarship on SESs. Limited capacities, such as resources, knowledge and skills, unsuitable incentive structures as well as conflicting organizational interests and values are just some of the factors that ultimately impact the potential for horizontal cooperation and the adaptive management of regional SESs. The failure to carefully examine the intertwined governance arrangements in which actors are embedded (e.g. the effect of the interplay of decentralization and more integrative management approaches) has hampered the ability of scholars and policy makers to recognize and address constraints to horizontal cooperation in regional SESs. Another unresolved issue is that while in the literature on SESs the importance of horizontal cooperation for effective governance, understood here as the successful co-production of services for public benefit, has been acknowledged (Teisman et al., 2013), the concept of horizontal cooperation has remained conceptually and empirical vague. This thesis addresses this research gap.

1.5. Research approach

This study adopts a relational approach that focuses on actor networks and collective action because such an approach captures the degree to which actors interact, commit resources, and comply with each other's rules. From this, important insights can be gained about the nature of, and conditions for, horizontal cooperation. Furthermore, using the patterns of interaction among a set of actors involved in the management of the SES as a point of departure, allows for the untangling of complex governance arrangements. In other words, the proposed approach clearly describes and specifies the actors, levels and modes that form part of these complex governance arrangements. While a relational approach will not be able to explain complex governance arrangements in their entirety, it provides a rich description of the processes that characterize them and in doing so allows for strengthened understanding on how conducive these arrangements are for horizontal cooperation and the adaptive management in regional SESs. The relational approach that informs this thesis is further strengthened through the integration of qualitative and quantitative research methodologies

(i.e. a social network analysis, focus groups and semi-structured interviews). That is, actor relations are examined through different means leading to a more holistic description of horizontal cooperation and to the cross-validation for specific research findings.

This study brings together understanding and concepts from different fields of research (see Figure 1-2) that have been concerned with the functions and dynamics of SESs and with the processes through which these systems are governed. What is distinctive to this thesis is the way the concepts from the different, yet overlapping, research fields have been combined to allow for a thorough investigation of horizontal cooperation in complex governance arrangements. Figure 1-2 identifies the different research fields with an indication from which disciplines they have originated. Because of their common interest in the human dimension of governance of SESs there has been a substantial amount of cross-fertilization between these fields with some of them using similar concepts. To avoid confusion in the subsequent chapters Figure 1-2 indicates which of the concepts discussed in this thesis are associated with which research field. Chapter 2 provides more information on the various research fields, and on how the different concepts have been defined and used in this thesis.

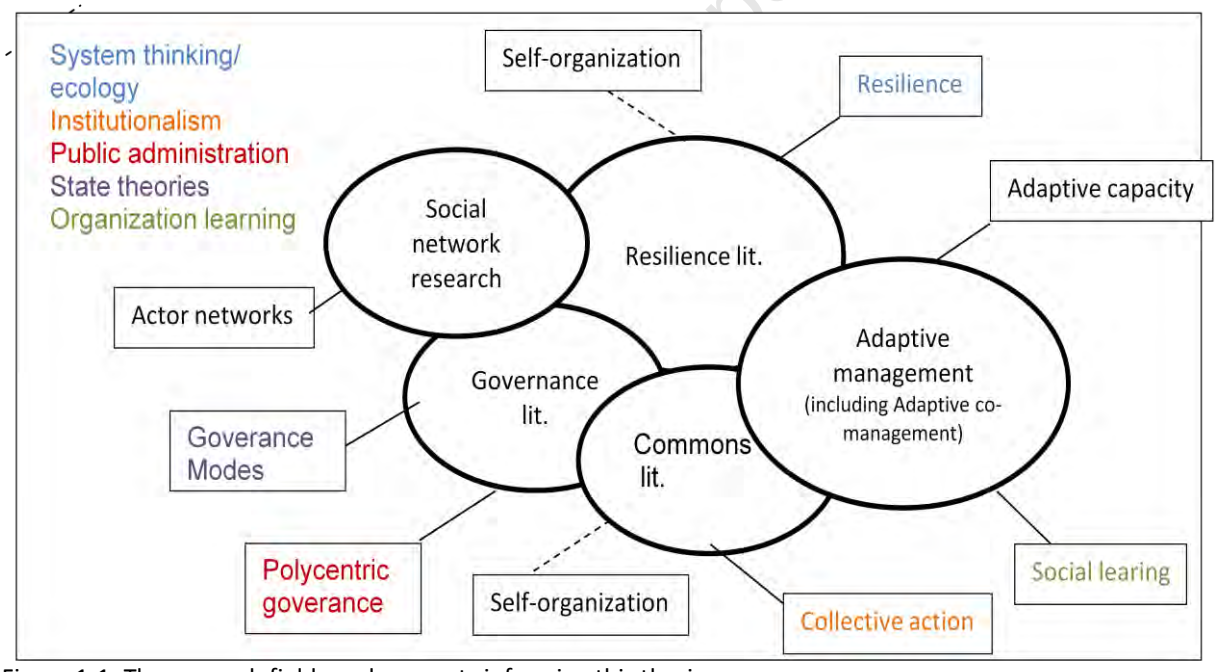

Figure 1-1: The research fields and concepts informing this thesis

1.6. Case Study Selection

In this thesis, complex governance arrangements that govern regional SESs are examined through an in-depth study of a South African catchment, namely the Berg River catchment.[11] More specifically, water governance is used to exemplify a governance system in which the operational level is affected by complex governance arrangements. The case study has been situated in South Africa because the

[11] The Berg River catchment is the Berg catchment from here on called.

country provides a good example where the opening up of the governance landscape and the rising complexity of governance arrangements can be observed. While South Africa has its individual setting, many of the developments and changes taking place in the realm of water governance can be observed in other countries as well:

- ***An adaptive and integrative approach*** to water management has been introduced (e.g. South Africa's National Water Act of 1998 is based on the IWRM principles).
- The democratization of the country through means of ***decentralization***.
- The ***restricted capacity*** of the government to effectively provide ***services for public benefit*** particularly in light of population growth and prevailing poverty.
- The ***persistent inequalities*** that exist in society which significantly affects the access to decision-making processes among the actors that have become involved in water management.[12]

Jointly these developments have significant impacted the operational level in South Africa's water governance system and the potential for horizontal cooperation among the actors involved in the management of South Africa's catchments. If these developments and their joint impact on the operational level are not accounted for thoroughly there is a risk that the opening up of South Africa's governance landscape will lead to: i. the reinforcement of existing power structures and the status quo, ii. that adaptive and integrative approaches for water management may be viewed as not feasible, and iii. that current and wicked societal problems can't be resolved and provision and production of services for public benefit is not secured.

1.7. Research aim and objectives

The overarching research aim is to investigate the role of horizontal cooperation in the adaptive management of regional SESs and to evaluate methods for developing a framework through which to measure horizontal cooperation. Approaching this aim requires conceptual development that brings to the fore key variables that need to be considered when evaluating horizontal cooperation. It furthermore necessitates the combination and advancement of complementary methodologies through which horizontal cooperation but also AM can be assessed. Finally, it demands that the proposed conceptual design and analytical framework are tested empirically.

[12] One of the major issues is, for example, the empowerment of actors that have been previously disadvantaged from political decision-making processes. Many of these stakeholders still lack the human (technical skills, formal education) and social capital (strategic linkages to formal decision makers, self-organization) to function as capacitated and competent actors in governance and management processes.

To ensure that the research aim is adequately addressed in this thesis the following research question has guided the investigation: When does horizontal cooperation contribute to adaptive management in complex governance arrangements?

The five research objectives described below will lay out the process in answering the research question. These objectives serve as specific milestones upon which the research and the subsequent thesis chapters have been structured.

Objective 1: Develop a conceptual design to better understand complex governance arrangements and the importance of horizontal cooperation by linking the concept of adaptive management and the concept of polycentric governance.

Objective 2: Operationalize the concept of actor networks and the concept of collective action for assessing horizontal cooperation in complex governance arrangements.

a. Introduce network heterogeneity and network cohesion as quantitative indicators for assessing horizontal cooperation.
b. Introduce Ostrom's eight design principles for identifying key constraints to collective action and for assessing the robustness of complex governance arrangements.

Objective 3: Analyze horizontal cooperation in the Berg catchment through a network perspective.

a. Identify the actor network involved in the management of the water resources in the Berg catchment (i.e. the Berg management network).
b. Assess horizontal cooperation based on the two network characteristics cohesion and heterogeneity.
c. Demonstrate how network cohesion and heterogeneity in the Berg management network influence learning and collective action among the organizations involved in the management.

Objective 4: Evaluate the existing governance arrangements that govern the Berg catchment.

a. Identify and describe constraints to collective action and self-organization in the Berg catchment.
b. Use Ostrom's eight design principles as indicators for testing the robustness of the existing governance arrangements.

Objective 5: Assess the contribution of a relational approach for providing new insights into horizontal cooperation.

1.8. Thesis outline

Chapter 2 presents the conceptual and theoretical background of this thesis and addresses *the first research objective* i.e. the development of a conceptual design applicable for the examination of complex governance arrangements. More specifically complex governance arrangements are approached through the focus on adaptive management (AM) and polycentric governance and a relational approach that focuses on actor networks. While the concept of AM emphasizes that governance arrangements need to cater for learning and collaboration in order to deal effectively with uncertainties and complexities that characterize SESs, the concept of polycentric governance enables the exploration of the intersection of different governance modes and their impact on horizontal cooperation. By linking the two concepts, a more nuanced and critical assessment of complex governance arrangements is possible. The third component of the conceptual design is a relational approach that is based on the research field of social networks. This approach directs the focus of attention to the patterns of interaction that link the various actors engaged in complex governance arrangements. These actor networks are the unit of analysis from which complex governance arrangements are investigated and their analysis provides the means for assessing horizontal cooperation in complex governance arrangements.

Chapter 3 describes the analytical framework that enables the rather abstract concept of horizontal cooperation to be measured by employing the two concepts *actor network* and *collective action*. In the first part of the chapter the concept of an actor network is discussed in relation to a quantitative analysis of horizontal cooperation through a formal social network analysis (SNA). More precisely, network heterogeneity and network cohesion are proposed as quantitative indicators for assessing horizontal cooperation. To gain a more qualitative understanding of horizontal cooperation i.e. the extent to which existing management issues are jointly addressed and key management functions are shared, the second part of the chapter focuses on the concept of collective action. Elinor Ostrom's (1990) eight design principles are introduced for identifying constraints to collective action and for assessing the robustness of the existing governance arrangements. By addressing *the second research objective*, Chapter 3 provides an important step for executing the assessment of horizontal cooperation in empirical settings.

Chapter 4 provides a rationale for why a single case study and a mixed method approach were employed to address the research aim. The chapter, furthermore, elaborates in greater detail how empirical data was generated and analyzed and also provides important contextual information on the Berg catchment as the research site.

Chapter 5 describes the findings from the SNA of the actor network through which the Berg catchment is currently managed. It is a comprehensive chapter that addresses *the third research*

objective. The chapter provides the detailed analyses and discussions that are essential to identifying and understanding the interacting processes that shape water management in the Berg catchment. The nature of the interconnected themes and the need to retain a holistic perspective precludes a separation of the analyses on network heterogeneity and cohesion. The chapter starts by first identifying and describing the actors involved in the management of the water resources in the Berg catchment i.e. the Berg management network. Based on the two network characteristics cohesion and heterogeneity, the horizontal cooperation within the Berg management network is assessed. The chapter shows to what extent the network cohesion and heterogeneity in the Berg management network influence learning and collective action among the organizations.

In Chapter 6 horizontal cooperation is assessed from a qualitative perspective through a focus on collective action. The chapter builds on the understanding gained in Chapter 5 and examines several collective action initiatives that have emerged in the Berg River management network. Each initiative is inspected with help of Ostrom's eight design principles which spell out conditions that help to account for successful, long-term collective action. In addition to aiding in the identification of constraints to collective action and self-organization in the Berg catchment, the design principles functions as valuable indicators for testing the robustness of the existing governance arrangements. Hence, Chapter 6 addresses research *the fourth research objective* of this thesis.

Finally, Chapter 7 synthesizes the understanding gained from previous chapters and in doing so addresses the *last research objective* of this thesis. The first part of the chapter reflects on the findings from the two empirical chapters. It does so in the context of the current state of water governance in South Africa and the appearance of and required conditions for management of regional SESs. The second part of the chapter turns more directly to evaluating the relevance of a relational approach for creating meaningful insights into horizontal cooperation and how it can be achieved in complex governance arrangements. The chapter closes by providing an outlook for future research opportunities.

2. Chapter: Conceptual design

The main aim of the chapter is to provide a conceptual design that assists in understanding and analyzing complex governance arrangements through a focus on horizontal cooperation. The design is an attempt to integrate and analyze key variables and processes that shape water management in regional SESs. Developing such a design is a challenging endeavor as some of the concepts, upon which the design is built, have their origins in different disciplines. A detailed discussion of the concepts (such as AM, collective action, self-organization, networks etc.), their original roots, and how they are defined and utilized in this thesis will reduce the risk of ambiguous meanings or interpretations.

This thesis approaches complex governance arrangements through a conceptual focus on adaptive management (AM) and polycentric governance. An AM approach, based on learning[13] and collaboration, is needed to deal with the complexities and uncertainties that characterize regional SESs as well as for managing such systems sustainably. The concept of polycentric governance on the other hand provides a framework through which complex governance arrangements can be assessed in terms of their potential for becoming functioning systems conducive to AM. In the literature on SESs, AM is often associated with network governance (see section 2.2.2). The advantage of making use of the concept of polycentric governance is that it acknowledges the existence, hybrid expressions and interdependencies of several governance modes (bureaucratic hierarchies, market structures and networks) in a governance system. It provides therefore more room for exploring their interplay and effect on horizontal cooperation.

The conceptual design shows how structural elements (e.g. actor networks, polycentric governance systems), process elements (e.g. AM, learning and collective action) as well as emerging elements (e.g. adaptive capacity, self-organization) in the governance system affect each other. The advantage of the proposed approach is that it does not predefine the relations between these elements. Rather, it allows them to emerge during the empirical analysis. Indeed the design was advanced through a constant conversation between theoretical understanding and empirical findings. The methodological tools utilized in this thesis, such as social network analysis (SNA) introduced in Chapter 3, made this possible. Although drawing any generalizations from a single case study is

[13] Based on Sol et al. (2013:37, and references therein) learning is understood in this thesis "as an interactive process that leads to some form of dissonance as a result to being exposed to alternative ways of seeing, knowing and understanding, coupled with a desire to overcome such dissonance by changing one's own thinking in sometimes subtle and sometimes more radical ways". Learning can lead to changes in perceptions, knowledge or behavior can be the outcome of learning processes in individuals or collective entities (such as organizations or groups).

unlikely, the in-depth analyses of the Berg River catchment allowed the detection and probing of the effects of different governance processes and variables on actor relations and vice versa.

The chapter starts with a brief discussion of why the thesis uses AM as its conceptual foundation, and how two of its defining features, learning and collaboration, could be realized in complex governance systems. Attention is given to the concept of polycentric governance as it speaks to the realities of contemporary water governance in regional SESs and provides possibilities for enhancing learning and collaboration through features such as redundancy, flexibility, and diversity. This is followed by proposing a relational approach that uses a social network perspective (with a focus on actor networks) as a starting point for assessing horizontal cooperation in complex governance arrangements. The chapter concludes with a reflection on the proposed definition of horizontal cooperation.

2.1. Adaptive water governance in complex governance arrangements

2.1.1. Adaptive management

Chapter 1 highlighted that catchments are SESs in which complexity[14] and uncertainties[15] have become two of the defining system properties. Whereas previous approaches to water management have for the most part ignored the complexity of these systems and attempted to reduce uncertainties through control, the concept of AM explicitly acknowledges the complexity of SESs and their related uncertainties (Walters, 1968; Holling, 1978; Gunderson and Holling, 2002; Lee, 1999; Pahl-Wostl, 2002 and 2007). Based on the understanding that uncertainties will prevail and need to be dealt with explicitly in an open and systematic way, the management goal has shifted from finding optimal solutions to increasing the adaptive capacity (AC) to learn from and better deal with developments resulting from uncertainty (Brugnach et al., 2008; Pahl-Wostl, 2009; Chapin III et al., 2009). Pahl-Wostl and Sendzimir (2005:5) propose that "[m]anagement must be adaptive and include the ability to change management practices based on new insights".

While the concept of AM has its origin in several disciplines and practitioner fields (Medema et al., 2008), most of the understanding in the area of water management derives from the study of

[14] Complexity often occurs in situations where many overlapping features and processes exist and where their cause effect relationships are not well understood (Light et al., 2013). It is a product of multiple causality as well as emergence and contributes to uncertainty (Light et al., 2013).

[15] Several types of uncertainties exist which relate to the lack of knowledge of the system (e.g. because of data gaps) lack of understanding of the system (e.g. because of non-linear processes and behaviour of system components), and the multiple perceptions and frames employed by stakeholders to define and understand the system (Pahl-Wostl et al., 2007). See Brugnach et al. (2008) for a more detailed discussion on uncertainties.

ecosystem management (e.g. Holling, 1978; Walters, 1986; Lee, 1993). The concept has evolved from a specific management tool mainly used in the management of ecosystems to an interdisciplinary research field on SESs that builds on substantial theoretical understandings (Termeer et al., 2010; Roux et al., 2006). So has for example, in the realm of water management, AM's original focus on the testing of hypotheses and on carrying out management as an experiment been subsequently altered and is now more broadly referred as a learning based approach i.e. a systematic process of learning by doing and adapting based on what has been learned (e.g. (Pahl-Wostl et al., 2007). As the concept found more and more application in real-life setting it became apparent that the concept needed to more explicitly cater for the multi-stakeholder context in/through which SESs are often managed. Some scholars have coined the term adaptive co-management[16] and distinguish it from AM to explicitly bring attention to the sharing of responsibilities and power and mutual learning among a heterogeneous set of actors/stakeholders(e.g. Moberg and Galaz, 2005, Armitage et al., 2007; Berkes 2009). In this thesis adaptive co-management is situated within the broader research field of AM.[17]

When defined and understood as an evolving and encompassing concept as well as research field AM sets out to provide a framework that integrates research, policy making and local practices in order to deal with the inherent complexity and unpredictability of dynamic SESs (Medema et al., 2008; Holling, 1978). Systematic monitoring of and critical reflection on the SES and the governance system become essential preconditions for improving management policies and practices through a learning based approach. "By re-evaluating goals, objectives and means by which to achieve them as new information and insight become available, AM is more responsive to changing conditions of, and demands on, ecosystems as compared with traditional approaches to water resource management." (Huntjens et al., 2011:148). Rather than providing a specific definition, AM is used and understood in this thesis as an approach through which a better understanding of the SES, the impact of human

[16] Adaptive co-management is often described as the merging of the concept of co-management (i.e. the sharing of responsibility between the state and resource users) and adaptive management (here understood as processes of interactive processes of learning and adapting) (Berkes, 2009). A definition for adaptive co-management that has been frequently referred was provided by Folke et al. (2002: 20) which describes it as ''a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing''. This is very much in line with how the concept of AM has been described and defined in this thesis.

[17] Please note that the author of this thesis will not go into the debate on differences between AM and adaptive co-management. Important for the reader to know is that contributions from the adaptive co-management literature, which are of great value to this thesis have been integrated into the discussion of adaptive management. Other authors such as Pahl-Wostl et al. (2007) and Huitema et al (2009) have taken a similar standpoint on this scholarly debate.

behavior on the SES, as well as the impact of the existing governance system on human behavior and the SES can be obtained. Two of its most important features, learning and collaboration, determine jointly the adjustment of management practices and institutions to changing conditions and prevailing uncertainties. These two features are described in Section 2.1.1.2.

2.1.1.1. The importance of adaptive management for the governance system

One of the primary objectives of AM is to enhance the adaptive capacity (AC) of the governance system (Pahl-Wostl, 2007). Broadly speaking, AC is a precondition for a system to be able to adapt to change by either altering some of its processes or, if required, to transform some of its structural elements (Pahl-Wostl, 2009). In social systems, AC is represented by the set of available resources (such as economic capital, physical resources, social capital, institutional arrangements and human capital) as well as the ability to mobilize these resources (Nelson et al., 2007). AC is often understood as the capacity of actors in a system to influence resilience (Folke et al., 2010).[18] Resilience, which is understood here as a property of the SES, refers to the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Berkes and Ross, 2013:6, referencing Walker et al., 2004). Through AC, which is a latent property within the social part of the SES, actors are able to manage the resilience of the SES by exercising their agency (Berkes and Ross, 2013; Lebel et al., 2006). Hence, actors can anticipate change and use their learning capacities to mobilize the necessary social and political means for managing resilience. The flexibility and adaptability which is fostered through the AM approach enhances the capacity to innovate and to find policies and practices that enhance the resilience and sustainability of the SES (Medema, 2005).

In light of the wicked societal problems (Rittel and Weber, 1973) that require multi-level and cross-scale responses, utilizing AC and actually increasing its potential has become imperative (Chapin III et al., 2008). AM can enhance AC by taking advantage of, and where necessary reconfiguring, existing structures according to where capacities and resources are located in the system (Folke et al., 2005; Hahn, 2011). In other words, the aim is to make use of the self-organizing properties of the SES and the governance system (Pollard and du Toit, 2011). AC can further be strengthened through joint learning processes that lead to holistic problem definitions, to innovative ideas and to collective actions through which existing resources are combined and problems can be addressed at the

[18] This line of argumentation implies two things. Firstly, it points to the need for learning about the SES (including its dynamics, internal and external inter-linkages, determinants of change, etc.) in order to be able to manage resilience in an informed manner (Berkes et al., 2003). Secondly, it also calls attention to the need for collective action and collaborative governance, as the management of such a system involves a multitude of state and non-state actors.

adequate levels (Chapin III et al., 2010). While learning, in particular iterative collective learning, has always been an integral part of AM (Pahl-Wostl, 2007; 2009), more recently the importance of collaboration in AM has been emphasized (e.g., Armitage et al., 2009; Robinson and Berkes, 2011). In the context of enhancing AC through AM, collaboration does not only bring about a greater pool of resources, it can aid the transformational change (Chapin III et al., 2010) which may be required to overcome mismanagement or to move the SES into a more desirable state. Hence, the two features of AM, learning and collaboration, are of critical importance for the AC of the governance system and the resilience of the SES. It is argued in this study that it is particularly important to mobilize the self-organizing properties at the operational level so that actors working at this level have the necessary resources available to co-produce services for public benefit and to maintain a functioning management system.

2.1.1.2. Two features of AM: learning and collaboration

Learning, in particular collective learning, is a key feature of AM for several reasons. The iterative and inclusive learning processes promoted by AM enhance the ability by a range of actors to create a better understanding of the SES as well as its governing system in spite of inherent uncertainties and complexity (e.g. Pahl-Wostl, 2007; Lebel et al., 2006). This in turn helps to develop robust policies and strategies that improve human behavior towards ecosystems (Biggs et al., 2012). A specific form of collective learning is social learning (Muro and Jeffrey, 2008). This form of learning is often viewed as an essential precursor for moving towards an AM approach in governance systems that have been dominated by the traditional command and control approach (Pahl-Wostl et al., 2007). Social learning[19] refers here to "a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks" (Reed et al., 2010). Social learning facilitates the co-production of knowledge, the development of shared meanings, and the reframing and creating of shared mental models (Pahl-Wostl, 2002, 2006; Scholz et al.,2013). Social learning processes are not so important for establishing a consensus, but are for recognizing and reconsidering existing frames, questioning underlying assumptions, and creating a critical level of trust among actors upon which new collaborative relations can be built (Sol et al., 2013). A final goal of social learning is to provide the necessary preconditions (agree on some ground rules, framing of a problem etc.) that are essential

[19] Within social learning, iterative reflection takes place when experiences, ideas and environments are shared (Keen et al., 2005). Social learning is a collective process, but one that has impact both at the individual and collective (e.g. community and institutional) level. The interactions among stakeholders may not only encourage the co-production of knowledge but also motivate the changing of understanding within the individual (e.g. he/she may develop a different relationship to others and/or her environment because of the interaction).

for coming to some agreement on collective action (Muro and Jeffrey, 2008). Hence, social learning might be characterized as an important condition for collective action, a specific expression of collaboration, which is of interest to this thesis.

Collaboration has become a defining feature and requirement of AM simply for the reason that with the opening of the governance landscape (discussed in Chapter 1), the number of actors involved in the management of SESs has increased (Bakker and Morinville, 2013,; Newell et al., 2012). In this context, resources and decision-making authority are often disbursed among different actors operative at various levels (ibid.). Furthermore, as mentioned above many management issues are wicked problems (or at least problems involving multiple scales). These problems can not be addressed effectively by individual actors operative at a particular level, thus collaboration is needed. Building on Imperial (2005:286 and references therein), collaboration is defined in this study as a "joint activity, by two or more organizations intended to create public value by working together rather than separately". More specifically, it describes a sophisticated and enduring form of interaction among two or more actors (including organizations) that pools understanding and resources to address issues that none of the actors can address effectively on their own (Gray 1985, Fish et al., 2010; Emerson et al., 2011). Furthermore, collaboration is an interactive and dynamic process involving deliberation, problem definition, goal-setting and the creation of rules and structures governing their relationships (Ansell and Gash, 2007). Such a process cannot be easily enforced and therefore requires some voluntary commitment by the actors involved. That is, no actor has the power or authority to compel others to act (Imperial, 2005). Collaboration can take various forms and can be initiated from within a group of actors or externally by means of incentive structures. Collaborations can refer to formal engagements between governmental and non-governmental actors but also to other types of initiatives such as community based co-management, private-public, or private-social partnerships. Although they differ in their levels of formality, what unites these arrangements is the aim of jointly creating a public value which has been specified in this thesis as the co-production of services for public benefit.

Cross-boundary collaboration, which is achieved through cross-scale and cross-level interactions, has been particularly emphasized in AM (Armitage and Plummer, 2010). It speaks to the need to establish the linkages among organizations from different administrative levels or different, yet related, policy fields (including relevant stakeholder groups) (Huitema et al., 2009, Termeer et al., 2010). Kallis et al. (2009) emphasize that to be of value for AM, collaboration must go beyond choosing between predefined interests to find consensus. Along those lines, Fish et al. (2010) state that in order to be an effective governance mechanism for adaptive water management, collaborative engagement necessitates that actors re-evaluate basic assumptions, attitudes and

values through iterative processes of knowledge exchange, dialogue, deliberation and negotiation. Hence, in the context of AM, collaboration must be accommodated by learning, in particular social learning processes that transcend different scales and levels (e.g. Armitage et al., 2008a; Robinson and Berkes, 2011; Wynborn, 2014).

This thesis is interested in a particular expression of collaboration, namely collective action. Broadly speaking, collective action is comprised of a concerted group effort to achieve common interests (e.g. Meinzen Dick et al., 2004; Ratner et al., 2013; Vanni 2013). It is a social process that results from regular interactions and entails the pooling of resources which then leads to concrete joint activities (Poteete and Ostrom, 2004). Meinzen-Dick and Di Gregorio (2004) state that in the realm of natural resource management, collective action has become an indispensable element. Similarly, Poteete and Ostrom (2004:438) argue that in order "to sustain long-term use of renewable resource systems …. collective action is needed to limit resource use and to undertake various forms of active management". The need for collective action is especially evident in the context of economic globalization and environmental degradation under which individual actors, in particular the state, are no longer able to effectively address on their own subsequent changes and stressors that impact SESs. It is not just the increasing awareness of interdependencies among actors sharing specific natural resources that makes collective action a viable governance mechanism, but there is also increased recognition that collective action allows actors to draw on different resources (e.g. knowledge, skills, and technologies) (e.g., Shrestha, 2013). Through collective action, the tangible (e.g. material and financial resources) and less tangible (e.g. knowledge, innovation) resources available to the actors involved in the management of the SES can be mobilized and distributed. In this way, collective action strengthens AC (Marshall, 2013). It allows for risk sharing (Carlsson and Sandstöm, 2008) and for the sharing of capacities (Adger, 2003; Ireland and Thomalla, 2011). Hence, collective action has gained significant importance in the co-production of services for public benefit (in this thesis exemplified through joint management of the Berg River catchment) as it provides a means for sharing costs and responsibilities (e.g. Vanni, 2013).

Chapter 3 will explain in great detail how the concept of collective action is specified and operationalized in this thesis based on Elinor Ostom's work on common pool resources. Figure 2-1 shows how collective action relates to AM, learning, and collaboration. AM takes place where collaboration and learning intersect. Although collective action is understood in this thesis as a specific expression of collaboration, Figure 2-1 indicates that not all collective action is voluntary. In situations where collective action results from coercive or compulsory pressure,[20] the willingness to

[20] In conventional hierarchical governance approaches co-operative agreements and practices can also lead to collective action. However, such arrangements are mainly short-term and actors continue to pursue separate

collaborate will be minimal and the cost to sustain collective action will be extremely high. Hence, a further assumption is that the cost for collective action will be the lowest where learning and collaboration intersect. Joint learning processes, for example, enhance the legitimacy of specific decisions and allow for the identification of common interests and goals (Berkes, 2009). Existing collaborative relations, on the other hand, can reduce transaction costs because previous interactions have already strengthened trust and reciprocity among the actors (Axelrod, 1984).

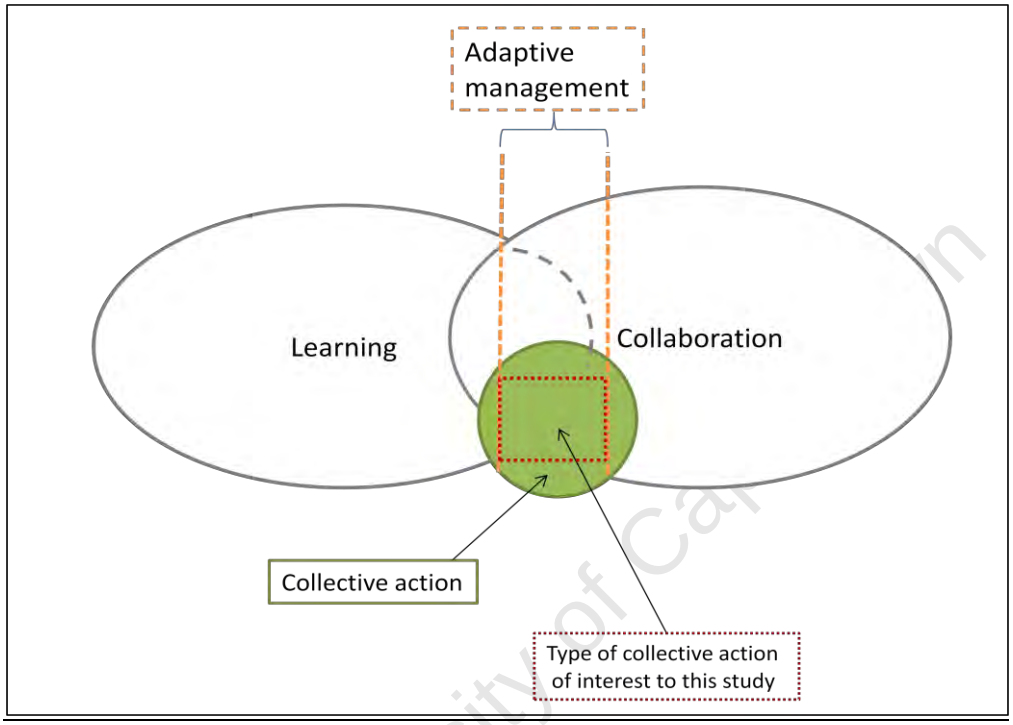

Figure 2-1: Specifying the relationship among collaboration, collective action and AM

The previous sections demonstrated the importance of learning and collaboration in AM and how the two features enhance each other in theory. In real world governance settings, learning and collaboration are not easily achievable. Both features necessitate the presence of specific institutional and relational capacities within the governance system .[21] Learning, in the context of AM, requires the constant uptake of (new) information, the integration of different knowledge sources,

goals and objectives. Decision-making processes remain largely in the control of higher level authorities e.g. a national department forces local government agencies to work jointly (Ueteka, 2012).

[21] Other scholars have also pointed toward the institutional challenges that inhibit the realization of AM. Some scholars have even questioned whether current management systems that have evolved in a traditional command and control paradigm can provide the structural requirements needed for the implementation of AM. Others have argued that learning processes and experimentation are too costly and time consuming, large scale experimentation not feasible, ecological and economic risks too high, and not have enough empirical evidence to demonstrate the success (process and outcome) of the approach (Medema et al., 2008).

and the subsequent co-production of knowledge (Pahl-Wostl and Hare, 2004). Medema et al. (2008: 12), for example, state that "[L]earning is information intensive and requires the active participation of many stakeholders, who need to maintain a commitment to the learning process throughout." This shows that a learning approach that includes experimentation, transparent and open communication systems, and reframing processes is resource intensive in terms of time and costs (e.g. Mostert, 2003; Newig and Fritsch, 2009). In particular, social learning requires the presence of a certain level of predictability and coherence in the governance system so that enough social capital and trust can be developed (Pahl-Wostl et al., 2007). Furthermore, these learning processes cannot just be confined to policy makers or managers but must activate 'societal' learning that can change prevailing unsustainable practices and governance systems (Pahl-Wostl, 2009; Reed et al., 2010). Collaboration, on the other hand, necessitates flexible institutions that allow for a pooling of resources as well as coordination mechanisms through which actions can be prioritized and existing practices changed.

Furthermore, it needs to be noted that collaboration and learning are not neutral processes but often shaped by existing power relations (Ansell and Gash, 2007; Armitage et al., 2008a). In situations where strong power disparities among the actors exist "the rules of collaboration are likely to favour entrenched, previous organized or concentrated interests (Fung and Wright, 2003: 263-4 in Brown 2011:3). With regard to learning it is often the more powerful actors that have access to valuable knowledge and information and who can decide which knowledge is viewed as legitimate in the deliberation processes. Under certain circumstances collaboration as well as learning processes can increase the democratic deficit (Lemos and Agrawal, 2006). That is, powerful actors can impose their interests because they have better access to and expertise in using available processes and mechanisms.

This thesis suggests that one reason for the challenge of implementing AM approaches might be based on a conceptual weakness. That is, AM is often associated with network governance. Scholars from the field have placed a lot of emphasis on networks as enabling AM (e.g Folke et al., 2005, Armitage et al.,2009, Berkes 2009, Tompkins and Adger 2004,). Theoretical arguments and empirical evidence have supported the view that network-like governance arrangements can be particularly conducive for facilitating learning processes as well as collaboration across levels and scales (e.g. Newig et al., 2010). Furthermore, network-defining characteristics such as self-organization and emerging properties have also been described as AM principles (Engle, 2011). However, the isolated focus on network governance seems to have distracted scholars from paying adequate attention to the impact and intersection of other modes of governance (e.g. hierarchies and markets) and corresponding institutions. Rogers et al. (2000:506) warned for example already a decade ago that

"[t]here is a tendency to superimpose the adaptive management process on old, usually bureaucratic, institutional structures and processes." In the context of complex governance arrangements, it is important to consider the effect of the different governance modes on horizontal cooperation jointly. Otherwise strategies to overcome obstacles to learning and collaboration may not be particularly effective. The concept of polycentric governance acknowledges the existence, hybrid expressions, and interdependencies of several governance modes in a governance system. The concept consequently provides the required conceptual space for assessing complex governance arrangements in terms of their potential for becoming functioning systems conducive for AM without over-emphasizing a particular mode of governance (i.e. network governance).

2.1.2. Polycentric governance systems

Polycentric governance systems consist of multiple, sometimes overlapping, decision-making centers that are characterized by partial autonomy and a shared set of rules.[22] Proponents of such systems argue that they provide opportunities for the realization of AM as their components and processes create many opportunities for learning and experimentation and a greater ability to adapt to a changing environment (e.g. Ostrom, 2005; Pahl-Wostl 2009; Silveira and Richards, 2013). Their institutional design considers a multi-actor, multi-level and multi-mode governance context and allows for various degrees of freedom among the diverse centers of decision-making (Folke et al., 2005; Pahl-Wostl 2009; Ostrom, 2010). This in turn, facilitates self-organization and the subsequent adjustments of policies and management practices to local context and available capacities (Biggs et al., 2012).

The term 'polycentricity' was introduced by V. Ostrom and his colleagues in their influential article on polycentric governance in metropolitan areas (Ostrom et al., 1961). According to them, polycentric governance refers to "many centres of decision-making that are formally independent of each other […] to the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts" (Ostrom, 2010:552). The advantage of effective polycentric systems is that they are able to balance bottom-up and top-down processes and establish cooperative links between the different centers of decision-making and thus "tend to enhance innovation learning, adaptation, trustworthiness, levels of cooperation… and the achievement of more effective, equitable, and sustainable outcomes at multiple scales" (Ostrom, 2010:552; Pahl-Wostl et al., 2012).

[22] Decision-making centers can refer to individuals, organizations or inter-organizational platforms. In this thesis they are organizations or organizational platforms that take part in the joint management of the Berg River.

One of the main arguments as to why polycentric governance systems are so suitable for implementing AM is that they have the ability to provide for the necessary redundancy as well as flexibility resultant form the inherent diversity (Biggs et al., 2012; Skelcher, 2005). That is, the overlapping realms of responsibility (i.e. political authority) and functional capacities among a diverse set of actors provide many opportunities for producing services for public benefit, for addressing existing issues at the appropriate scale, as well as for the facilitation of self-organization and knowledge co-production across scales (McGinnis and Ostrom, 2011; Pahl-Wostl 2009; Biggs et al., 2012; Lebel et al., 2006). It is further assumed that redundancy allows decision-making centers (actors/organizations) to take over functions that others may, under certain circumstance, no longer be able to fulfill (Berkes et al.,2003; Kofinas, 2010). Hence, institutional failure at one level or at a decision-making unit is compensated for by actions taken somewhere else in the system (Biggs et al., 2012; Sovacool, 2011). Furthermore, the participation of a wide array of actors in the production of services for public benefit provides ample opportunities for state and non-state actors to "negotiate solutions suited to the distinct problems faced by each community" (McGinnis and Ostrom, 2011:15). In this way, it is assumed, the adequate utilization of available resources and competencies is enhanced. Claims have also been made that polycentric systems tend to be more resilient in comparison to mono-centric systems (Folke et al., 2005; Galaz et al., 2012).

Another reason for linking the concept of AM to the concept of polycentric governance is that the concept of polycentric governance does account for the various governance modes that might be at play. In other words, from a polycentric governance perspective social coordination is not steered solely through one particular governance mode (bureaucratic hierarchies, markets or networks). Rather "[t]op-down, bottom-up, network and side-by- side governance elements exist in parallel" (Pahl-Wostl 2009: 363). Although Ostrom never explicit linking polycentric governance and governance modes the way she has used and advanced the concept of polycentric governance provides the necessary space to explore the intersections of the modes. For this reason polycentric governance is used in this thesis as a guiding theory for investigating horizontal cooperation in complex governance arrangements.

Yet, when can one actually speak of polycentric systems and how do they differ from fragmented systems or other multilevel systems? Vincent Ostrom and colleagues argue that one needs to look at the relationships among the various decision-making units. Only when they function in a coherent manner and show consistent patterns of interaction can one speak of a system (V. Ostrom et al., 1961). Ostrom referred frequently to a shared set of rules. However, what this entails in context of governance of regional SESs remains vague.

The discussion on polycentric governance systems seems to be even more complicated in the realm of water governance. Huitema et al. (2009) point out that in empirical terms all water management systems are polycentric. Similarly, da Silveira and Richards (2013:320) argue that "[t]he multiple substantive policy areas to be addressed in river basin governance, the diverse scales at which the issues driving these policies arise and are managed, and the persistent lack of fit between natural, political and administrative spatial units all imply that polycentricity is likely to be a natural characteristic of river basin governance". Focusing more specifically on the operational level itself, Marshall (2013) point out that most management functions are interdependent, shifting and dispersed across different administrative and sectoral boundaries. In other words, because of the interdependencies, the social organization is already structured this way. In many settings the cost would therefore be too high to try to enforce or maintain a mono-centric approach on water resource governance. Yet, it also has become evident that water governance systems differ greatly in their degree of polycentricity and their characteristics. Hence, not all polycentric systems are functional nor are all conducive for AM. Therefore, the aim should be to find means to get the different decision making-centers in each particular setting to function in an integrated and coherent way (Marshall, 2013).

Theoretical understanding and empirical evidence (e.g. from large scale case study projects such as the Twin2go project[23]) have supported the hypothesis that polycentric systems provide for the institutional dynamics important for AM. However, the discussion above implies that the limited understanding and clarity of the very features that define polycentric systems leave important questions unanswered (Galaz et al., 2012). Furthermore, despite the fact that the importance of horizontal cooperation in these systems has been acknowledged, how coherence and coordination is achieved through horizontal cooperation remains theoretically and empirically not well understood. Thus, more nuanced and detailed studies investigating polycentric systems and the role of horizontal cooperation are required.

A focus on the linkages among the decision-making centers seems to be an especially promising approach for gaining more insight into the functioning of polycentric systems. (see for example Galaz

[23] Pahl-Wostl et al. (2012) show in their comparative analysis across a range of case studies that polycentric systems perform higher than centralized or fragmented systems. In their meta-analysis of 47 case studies, Newig and Fritsch (2009:210) came to the conclusion that the "analysis suggests that a highly polycentric governance system comprising many agencies and levels of governance yields higher environmental outputs than rather mono-centric governance."

et al., 2012[24] and Silveira and Richards, 2013). Silveira and Richards (2013), who investigated water quality management in the Rhine River basin, Germany, and the Zhujiang River basin, China, point to the critical role of functional operational links through which key management functions in polycentric systems can be performed.[25] They further argue that incentive structures at different levels are critical for the establishment of such cooperative links and conclude that "the influence of a polycentric governance system on adaptive capacity depends on the internal power dynamics among the components of a system" (Silveira and Richards, 2013:319).

This suggests that in order to understand the functioning of polycentric systems, close attention needs to be paid to the patterns of interactions among the decision-making centers within such systems. This can contribute to a greater clarity of the key features of polycentric systems. Furthermore, by examining the patterns of interactions, the existence and nature of shared rules can be probed, and the intersections of governance modes can be explored. A relational focus can also aid in understanding how functional linkages are created and maintained in such systems. It is argued in this thesis that these linkages need to be investigated not only to better understand how they provide for flexibility and redundancy in the system but also how they facilitate coordination and the required coherence through which key management functions are maintained.

To summarize the preceding discussion, the SES community has emphasized that governance arrangements need to consider complexity and uncertainties. This can be achieved through adaptive management based on learning and collaboration. Yet, little is known about the extent to which learning and collaboration (in the expression of collective action) is possible in regional SESs that are managed through complex governance arrangements. By linking the concept of AM to the concept of polycentric governance, a more nuanced and critical assessment of complex governance arrangements is possible. The concept of polycentric governance also addresses a shortcoming of AM; rather than limiting the discussion to network governance, the concept enables the exploration of the intersection of different governance modes and their impact on horizontal cooperation in complex governance arrangements.

[24] Investigating polycentric order through a focus on a global initiative among international organizations Galaz and colleagues (2012) showed that the network features of such systems can provide useful insights into the degree of polycentricity within a system. According to them polycentric systems are characterized by dense collaboration patterns and institutionalization that allows for uniformity and consistency (Galaz et al., 2012).

[25] The authors (2013:321) define a functional polycentric governance system as "one that has developed the internal operational linkages that enable it to perform critical functions, such as the systematic exchange of data and information during processes of experimentation, monitoring, and learning".

The discussion above also highlighted the point that so far neither theory nor empirical evidence has provided an adequate understanding of the features that relate to horizontal cooperation (including coordination and coherence) in complex governance arrangements. A relational perspective, i.e. a focus on the patterns of interactions that link the various actors engaged in complex governance arrangements, seems to be a promising approach. The next section will therefore turn to the discussion of how horizontal cooperation in complex governance arrangements can be assessed through a focus on actor networks.

2.2. Actor networks: a relational approach for assessing complex governance arrangements

The understanding of actor networks put forward in this thesis rests upon the relational approach that has been advanced by the literature on social networks (i.e. network research in particular SNA).[26] The SNA literature views networks as "a way of thinking about social systems that focus our attention on the relationships among the entities that make up the system" (Borgatti et al., 2013:1).[27] The following sections provide an overview of the research field and demonstrate why it is most suitable for the operationalization of the network concept and analyzing horizontal cooperation in complex governance arrangements. Please note that Chapter 3 will in detail describe how the network concept is going to be operationalized. Given that the term network has become a popular concept in the past few years and is used in various ways in the literature, the section starts with clarifying paragraphs that show how the term actor network is understood and investigated in this thesis.

2.2.1. Conceptualizing networks: network governance as mode of governance or actor network?

Over the past decades, networks have become a popular concept in many disciplines, especially among those concerned with issues of governance (Börzel, 2011; Klijn and Koppenjan, 2000; Kjaer, 2011; Sandström, 2008).[28] In the literature (e.g. public policy, state theories and organizational studies), networks are often associated with a specific mode of governance that can be contrasted to hierarchies or markets. They have also been used to describe more dynamic or fluid institutional

[26] Although most studies from that field refer to social networks rather than actor networks the author decided on actor networks because it makes it less confusing when terms such as network mode or governance network are also discussed in this thesis.

[27] These entities can be individuals or collectives such as organizations.

[28] Like the term 'governance', the term 'network' has been applied in different ways leading sometimes to contradicting statements. Another issue is that the term can easily be defined too narrowly or it is applied to almost everything and therefore loses its analytical power.

arrangements such as shadow networks (High et al., 2005), policy networks (Klijn and Koppenjan, 2000) or epistemic communities (Haas, 1992). [29] The term network governance has primarily been advanced within organizational studies (e.g. Alter and Hage, 1993) and state theories (Rhodes, 1997). In its most general form, network governance describes non-hierarchical patterns of interactions and political steering among actors that represent different sectors and different levels (Hirschi, 2010). Newig et al. (2010) relate network governance to more stable forms of social coordination that have a cognitive dimension allowing for information transmission and learning aimed at fulfilling public purposes. Networks are often discussed in relation to characteristics such as open membership (i.e. the inclusion of state and non-state actors), flexibility (e.g. the emergence of leadership and institutions and new actor constellations), informality (e.g. it is often assumed that they are mainly governed by informal institutions), non-coercive steering (e.g. social sanctions or reputation), and self-regulation (Duit and Galaz; 2008; Pahl-Wostl, 2009; Larsson, 2013). It has further been argued that many of these characteristics make networks particularly conducive for facilitating learning processes, self-organizing as well as cross-level and cross-sector linkages (e.g. Newig et al., 2010).

Conceptualizing social networks in this way has helped to highlight the fact that the coordination and steering of social action[30] does not occur only through hierarchical command and control structures or market mechanisms. It has further led to the acknowledgement that certain social networks should be treated as discrete forms of governance that have "unique structural characteristics, modes of conflict resolution, bases of legitimacy, etc." (Provan and Kenis, 2007: 230). Yet, placing networks in direct opposition to hierarchies and market structures seems to be too narrow a definition and is not particularly helpful for understanding contemporary complex governance arrangements.[31] In this thesis, networks are seen as essential features of social systems that capture kind and structure of interpersonal relations among actors. Understanding such relations is essential to understand various governance arrangements. When viewed from this broader, yet inclusive perspective, a network may contain aspects of all three modes of governance, namely market structures, bureaucratic hierarchies, and informal networks (see Figure 2-2). This view therefore

[29] Networks have frequently been described as governance mechanisms that are temporary and issue specific, and as having been created as problem-solving devices.

[30] Social action may be understood as a negotiated process which is shaped by the interactions of actors who pursue their specific interests within the constraints of the resources and opportunities available to them (Coleman, 1990; Carlsson and Sandström, 2008).

[31] Carlsson and Sandström (2008: 49) for example write that "[a] common misconception about networks is the assumption of a non-hierarchical structure. The authors continue to argue that this hierarchical structuring may not reflect formal hierarchical (bureaucratic) relations but be resultant of the uneven state of resource dependency".

allows the capturing of formal and informal processes of social coordination, which derive from the different modes of governance and their interaction and which find expressions in actor networks (the unit of analysis in this thesis).

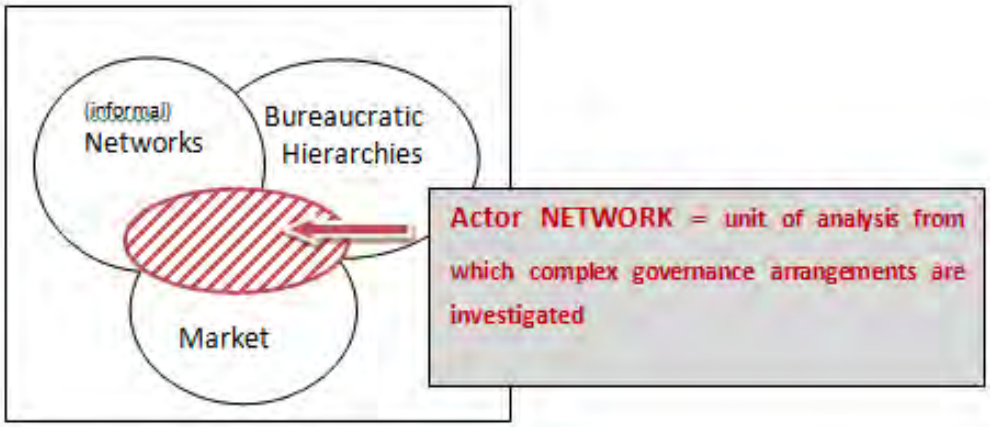

Figure 2-2: Illustration of how networks are conceptualized in this study

2.2.2. Actor networks conceptualized through a relational network perspective

SNA is an interdisciplinary research field with contributions from sociology, psychology, anthropology mathematics, statistics, information science, etc. (Scott, 2000). What unites the different disciplines is "[t]he use of structural and relational information to study and test theories" (Wasserman and Faust, 1994:21). Network research has its origin in the 1930s[32] and has been used in many different contexts that go far beyond the more recent 'network' governance debate (Borgatti et al., 2009). From a SNA perspective, social networks are made of a set of actors ('nodes') which are connected to one another through relations (ties) of a specified type (Wasserman and Faust, 1994). More specifically, the basic idea is that "[t]he patterns of ties in the network yields a particular structure, and nodes occupy positions within the structure" (Borgatti and Halgin, 2012:5). A relationship between two actors denotes a flow of resources which can be information and knowledge or tangible resources such as money (Wasserman and Faust, 1994).

Marsden (1990: 436) writes that "the approach seeks to describe social structure in terms of networks and to interpret the behavior of actors in light of their varying positions within the social structure". Through the employment of SNA, the relationships that define the structure of the network are modeled, which in turn allows the researcher to study impacts of the structure on the functioning of the network and its individual network members (Wassermann and Faust, 1994).[33]

[32] A good historic overview is provided in Wasserman and Faust (1994) as well as in Prell (2012).

[33] SNA is for example able to depict how actors have access to differential opportunities such as social support, social resources and social capital (Marsden, 1990).

This view is based on the assumption that "the characteristics of the social units arise out of structural or relational processes" (Wasserman and Faust, 1994: 7-8). According to this line of thinking, individuals do not respond or "react independently to circumstances based on their individual tastes, proclivities, and beliefs" and do not just "create new circumstances only by the simple aggregation of their actions" (Marin and Wellman, 2011:15). Instead, people's responses to change are the consequences of interactions, and outcomes are caused by the opportunities and constraints created by the different network positions (Emirbayer and Goodwin, 1994).

Bodin and Crona (2009: 367) point out that "when studying social networks it is important to specify which type of relations are being studied and how they relate to the research question". This statement implicitly highlights the fact that from a relational network perspective there is no such thing as 'the network'. It is the choice of tie (or combination of ties) that defines the positions of actors in the network. In other words, "each network will have its own structure and its own implications for the nodes involved" (Borgatti and Halgin, 2012).[34] In making the choice about which tie or ties to focus on, no claim is made that the actors only have relationships with other actors from within the actor set. In this way the network perspective does not claim that an actor's behavior is only determined by his or her interactions with actors from the network under investigation. Rather the perspective is able to discern key relational structures that link actors to specific governance contexts such as water management and to show how those relational structures shape their behaviour towards each other and the resource system.

The SNA approach has several advantages and unique perspectives which can enhance our understanding of complex governance arrangements:

i) It does not classify people according to their personal/ organizational traits (such as race, gender, education, sector, profit-orientation) but according to their patterns of relations. It makes it therefore possible to reveal drivers and processes that may remain ignored by approaches that focus solely on the characteristics of the individuals. This thinking does not deny that to a large extent "human action is organized through categorical affiliations (e.g. race or social classes), but it is motivated by the structure of social relations in which actors are embedded" (Bodin et al., 2011:9, referencing Emirbayer, 1997). Focusing only on attributes of actors would fail to detect how actors influence and are influenced by the patterns of relations in which they engage.[35]

[34] In other words, a network will change its structure and composition for different relations even if it comprises the same set of actors. For example, in this study the structure of the information exchange management network will look quite different from that of the collaborative management network.

[35] Borgatti and Mollina (2003: 337), for example, see "the network paradigm as a way to escape from the atomism of traditional social science in which individual behaviour—such as adoption of an innovation—is

ii) One of the major contributions that the social network literature has made in the field of governance (and particular environmental governance) is that it has been able to demonstrate that not "all social networks are created equal" (Newman and Dale, 2005: 1). Bodin and Crona (2009: 366) for example, highlight that "significant differences in governance processes and outcomes can be expected among networks experiencing structural differences in terms of density of relations, degree of cohesiveness, sub-group interconnectivity, and degree of network centralization". Multiple studies have shown that networks enhance (Dietz et al., 2003; Hahn et al., 2006; Newman and Dale, 2007; Sandström, 2008), but also could constrain (Ernstson et al., 2008; Crona and Bodin, 2006) adaptive management as they can facilitate or inhibit knowledge and information transmission, mobilization and allocation of resources, development of common rules and frameworks, and conflict resolution (Bodin and Crona, 2009). Network properties, therefore, play a vital role in the working of the network.

iii) SNA measures and techniques are guided by a formal theory that has its foundation in mathematics (graph theory and algorithms) (Wassermann and Faust, 1994). As a consequence social concepts such as social capital or horizontal cooperation can be expressed and measured formally through mathematical equations and hypotheses can be tested empirically (Borgatti et al., 2013).

iv) SNA tries to bridge the structure agency divide by acknowledging the embeddedness of individuals in larger structures (Bodin et al., 2011). Individual and collective actions are influenced by actors' previous relations. At the same time, many studies acknowledge the importance of agency and emerging structure in the networks (e.g. Bodin andPrell, 2011b; Ernstson et al., 2008). These studies point out for example that actors that have influential positions in the network (e.g. because they are connected to many others or because they connect actors or groups that would otherwise be disconnected) can drive or alter social processes, depending on how they use their influence in the network.

v) A network approach provides a multilevel perspective: it allows the researcher to move between actor, sub- group and whole network level (Burt et al., 2013). By being able to shift between macro and micro levels of analysis a comprehensive picture of the relational structure of complex governance arrangements is created.

To briefly summarize, through the study of social relations among a set of actors, the network concept has been advanced within the interdisciplinary field of social networks (i.e. SNA). The core idea upon which a SNA builds is that of "[t]he structure of relations among actors and location of

---

analysed solely in terms of the attributes of the individual (e.g. openness to change, stake in the outcome, etc.) and not in terms of interpersonal transmission, influence processes, and other relational variables".

individual actors in the network have important behavioral, perceptual and attitudinal consequences both for the individual unit and for the system as a whole" (Knoke, 1990:9). The argument put forward in this thesis is that the network concept as put forward by the SNA, is able to capture the interaction of various governance modes and the emerging structure that arises out of the pattern of regular interaction among diverse sets of actors that constitute complex governance arrangements. Hence, this relational approach makes it possible to observe the extent to which the emerging structure as well as the interplay of governance modes in turn constrains the collaborative behavior of the actors. Network analysis based explanations provide, therefore, new important insights on the potential in adaptive management and horizontal cooperation in complex governance arrangements.

2.3. Advancing a concept of horizontal cooperation applicable for complex governance arrangements

This chapter has discussed the phenomenon of complex governance arrangements in relationship to the concept of AM and polycentric governance systems. In this context, the importance of horizontal cooperation for learning and collaboration as well as for the successful co-production of services for public benefit was highlighted. Furthermore, a relational approach that takes the pattern of interactions among a set of actors (actor network) as point of departure for assessing horizontal cooperation in complex governance arrangements has been advocated. The reason behind this choice is that in regional SESs, water management is, to a large extent, the outcome of the patterns of interactions among the actors that are participating in the management. However, the plurality of actors and the different degrees to which the various actors are embedded in the management system necessitates that the patterns of interactions among those actors are not looked at in isolation. The behavior of those actors toward each other will partially be influenced by other institutional and organizational structures in which they are embedded. An examination of actor networks that takes into account how larger governance arrangements affect horizontal cooperation is considered an important additional step to provide new insights. Chapter three will elaborate how the effect of larger governance arrangements can be taking into account with the help of Ostrom's eight design principles and a focus on collective action.

Horizontal cooperation was defined in Chapter 1 as collaborative, non-hierarchical interactions of actors across sectors, modes of governance and spatial scales. The proposed definition assumes that that the co-production of services for public benefit, learning, and collaboration require not only sectoral integration but also a coherence[36] of governance modes and existence of functional cross-

[36] Coherence of governance modes, as described in this thesis, is based on a normative standpoint with a focus on sustainable water management. Coherence of governance modes may be expressed through incentive structures aimed at similar goals, e.g. sustainable resource management. Furthermore, it means that actors,

boundary linkages. A focus on sectors is useful with regard to horizontal cooperation because sectors often describe needs and interests that specific actors may have in a resource. However, this classification appears to be too limited for capturing key variables and processes that shape water management in regional SESs. One way of unpacking how actors, which are embedded in complex governance arrangements, cooperate at the operational level is by looking at horizontal cooperation from a polycentric governance lens. It allows not only reflection on sectoral integration but also how the multi-level and multi-mode governance context in which actors are embedded affects their decision-making and their willingness to cooperate. Finally, cross-boundary linkages enable actors to interact across spatial scales as well as establish the required nestedness across administrative levels.

regardless of which mode their behaviour is primarily steered through, see the need to contribute to sustainable water management.

3. Chapter: Analytical framework: Operationalizing a relational approach on horizontal cooperation

Chapter 1 states that this thesis sets out to investigate the operational level in South Africa's water governance system (using the Berg catchment as the site of investigation). The main aim of Chapter 3 is to provide a thorough account of how the two concepts, actor network and collective action, have been operationalized in order to assess horizontal cooperation in complex governance arrangements. The former concept (actor network[37]) is primarily discussed in relation to a quantitative analysis of horizontal cooperation through a formal Social Network Analysis (SNA). The latter concept (collective action) allows for a qualitative analysis of horizontal cooperation. More specifically, it is with the help of Elinor Ostrom's (1990) eight design principles that constraints to collective action are identified and a judgment about the robustness of the governance arrangements that govern the Berg catchment is made. Figure 3-1 provides a simplified illustration of the analytical framework. By linking the quantitative analysis of actor networks with the qualitative analysis of collective action a relational approach is sought for describing and analyzing horizontal cooperation at the operational level in South Africa's water governance system. The relational perspective proposed in this thesis describes and investigates the functioning of governance systems with a focus on actor relations (including the institutions that shape the behavior of the actors to each other).

[37] Note that the set of actors that comprise the actor network under investigation are organizations and not individuals. A justification of why the focus has been placed on organizations and not on individuals is provided in Chapter 4.

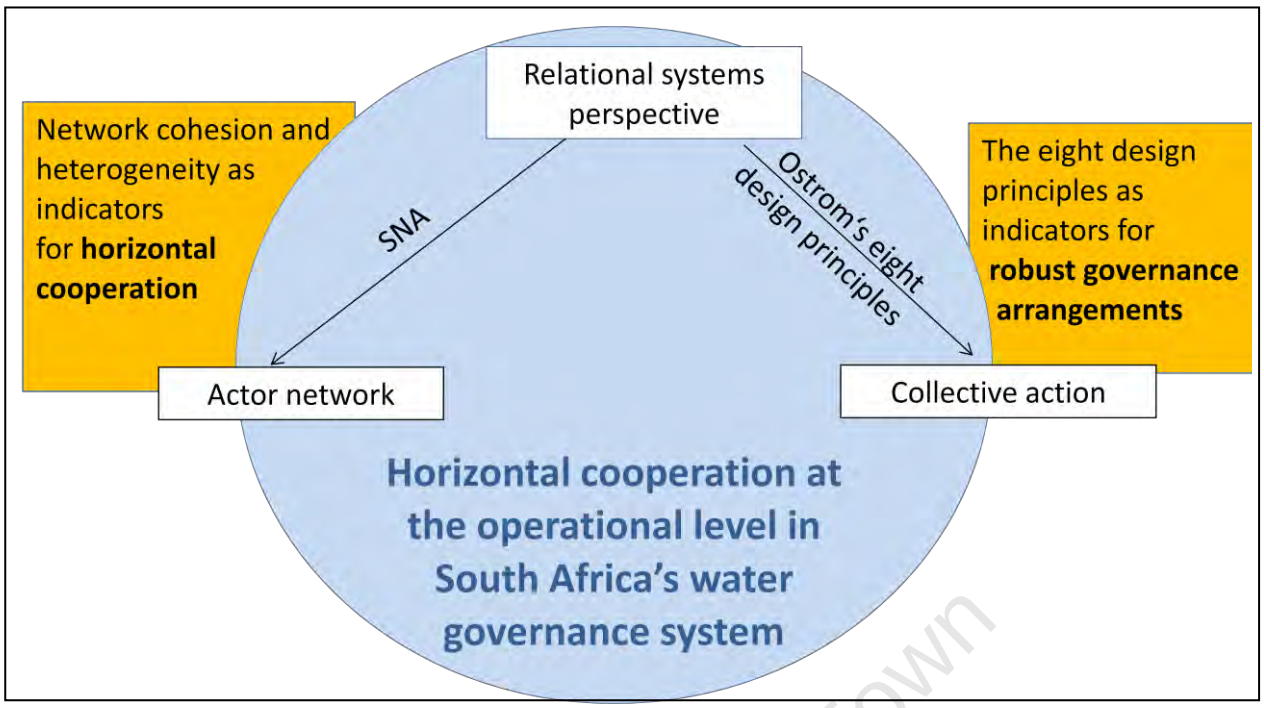

Figure 3-1: The proposed analytical framework for assessing horizontal cooperation

The primary intent of employing the SNA has been to examine how the relational structure of the actor network affects horizontal cooperation, the potential for learning processes, as well as collaboration in the Berg management network. The qualitative investigation into collective action, on the other hand, allows the exploration of the extent to which existing management issues are jointly addressed and key management functions are shared among actors. Hence, valuable insights into the constraints affecting collective action and the capacity to self-organize in the Berg catchment can be gained from scrutinizing different collective action initiatives. Collective action, which was defined in Chapter 2 as a specific expression of collaboration, can be viewed as an outcome variable of horizontal cooperation. This does not negate the insight that collective action is part of an iterative process that includes learning, negotiation and horizontal interaction. Consequently, collective action is also a feature that can strengthen horizontal cooperation. Both aspects are of relevance to this study.

The chapter is organized as follows. First, core assumptions and concepts put forward by the field of network research (in particular SNA) are described. Then, the relevance of SNA in the area of the management of SESs is described, followed by an illustration of how the properties of actor networks can affect social processes such as learning and collective action. Lastly, the two network characteristics, network heterogeneity and network cohesion as well as related network measures, are discussed in greater detail. From a relational perspective, cohesion refers to the interconnectedness between the different actors, i.e. how well connected they are. Heterogeneity refers here to the diversity of actors involved in the network and the extent of cross-boundary

linkages among them. It is with the help of these two network characteristics that horizontal cooperation in the Berg catchment is assessed in Chapter 5.

In the second part of the chapter (Section 3.2), the concept of collective action is presented through a consultation of the work by Elinor Ostrom on common pool resources[38]. First, characteristics of collective action are discussed based on 'the commons' literature. In this context the terms self-organization and self-governance are introduced. This is followed by turning to Ostrom's eight design principles (1990) and by providing a justification for their value to the analysis of collective action in regional SESs. Ostrom's design principles are then complemented by several organizing themes that are intended to detect additional factors fostering or inhibiting collective action in regional SESs. The proposed analytical approach for investigating collective action is applied in Chapter 6 which examines constraints on the selected collective action initiatives in the Berg catchment.

3.1. Understanding the management of regional SES through a network perspective

3.1.1. SNA: Patterns of relations as the primary unit for theorizing

Marin and Wellman (2011:17) state that SNA "is neither a theory nor a methodology". They continue by saying that SNA provides a specific way of looking at a problem. Borgatti and colleagues expand on the discussion by arguing that "…some social scientists, unfamiliar with formal theorizing, have misconceived the field as methodology. It does indeed have a distinct methodology that is born of its relational view of social phenomena. But the theoretical concepts …such as centrality and structural equivalence are just that: theoretical concepts that are part of a distinctive approach to explaining the social world" (Borgatti et al., 2013:10, referencing Borgatti and Halgin, 2011). This suggests that any study that aims to utilize SNA to help to explain a particular social phenomenon (rather than reducing it to a simple methodology measuring a few relations) must have a good understanding of the theoretical understandings and explanatory mechanisms upon which SNA builds. Marin and Wellman (2011:3) emphasize for example that "[t]aking social relations seriously calls for more than knowing how to measure some characteristics of networks, such as the density of their interconnections. It requires a set of assumptions about how best to describe and explain the social phenomena of interest." It is for this reason that Box 3.1 captures succinctly what it means when patterns of relations between actors become the primary unit for sociological theorizing and

[38]Common pool resources (CPRs) refer to "resource systems regardless of the property rights involved. CPRs include natural and human constructed resources in which (i) exclusion of beneficiaries through physical and institutional means is especially costly, and (ii) exploitation by one user reduces resource availability for others." (Ostrom et al., 1999:278)" (Ostrom 2008:7).

research (Marin and Wellman, 2011). The focus is only on key ideas which have particular relevance for this study and which is discussed again in subsequent sections.

Box 3.1: Key network ideas of relevance to this study

The cost of relation:

SNA builds on the assumption that all relations come at a cost (Granovetter, 1973; Ernstson, 2008). It is not only the establishment of the relational ties but also their maintenance that require effort and costs. Since it is assumed that it takes more effort to establish new relations then existing ones, most resources will flow through already established relations. Furthermore, more intense patterns of interaction require more effort at maintenance than infrequent and shallow interactions.

Homophily:

A concept closely related to that of strong ties (and even cohesive sub-groups) is that of homophily. It refers to the tendency of actors who share specific attributes to also interact more frequently with each other (Prell et al., 2010; Newig et al., 2010). Because it is easy for like-minded actors to communicate and develop a common understanding, they are more attracted to each other (Prell et al., 2010). This reasoning is closely related to social influence theory (Friedkin, 2006).

Modularity:

Modularity refers to the tendency to form multiple groups within the network (Bodin et al., 2006). These cohesive sub-groups distinguish themselves from the rest of the network through high density of relations among the group members in comparison to the rest of the network. This allows for the development of specialized knowledge generation within the groups (Bodin and Crona, 2009). Yet, the development of a group identity may be based on an "us vs. them" demarcation making collaboration with other actors or groups from the network less likely.

Strong ties:

''The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, and intimacy (mutual confiding), and the reciprocal services which characterize the tie'' (Granovetter, 1973:1361). Actors sharing **strong ties**, often also referred to as a **bonding ties**, tend to share similar views, exert strong influence upon each other, and are able to communicate effectively and often develop high levels of trust towards each other (Prell et al., 2010). They tend to establish within groups of likeminded actors. One of the weaknesses of strong ties is that they often carry redundant information (Granovetter, 1973).

Weak ties:

They are also referred to as bridging ties and denote less frequent and less intense patterns of interactions. They tend to establish among actors that are rather dissimilar in their attributes (Prell et al., 2010). These type of ties are often the transmitter of different kinds of knowledge and resources

in a network and connect different segments of a network (Granovetter, 1973; Burt, 2001; Bodin and Crona, 2009). Unlike strong ties, weak ties are fragile in that they can easily be terminated and are not conducive to the development of trust or close cooperation (Bodin and Crona, 2009). According to Granovetter's (1973) **'strength of weak ties'** argument, weak ties provide bridges between different segments or groups in the network and are carriers of non-redundant information. Based on this understanding, it is assumed that most opportunities as well as innovations will arise out of weak patterns of interaction.

'Structural hole' argument (Burt 1992):

This concept has been developed by Burt, whose work was strongly influenced by Granovetter's strength of weak ties argument. Structural holes denote "missing relations inhibiting information flow between people" (Burt et al., 2013:529). It implies that different knowledge is created and gets communicated on either side of the hole. Using Burt's metaphor, "[a] structural hole is a buffer, like an insulator in an electric circuit. People on either side of the hole circulate in different flows of information" (Burt et al., 2013:529). Actors that can bridge structural holes have the potential to act as brokers that fulfill a bridging role in the network (Bodin et al., 2006).

3.1.2. Network structure and management of SES: linking network properties and social processes

SNA has particular relevance for the area of the management of SESs (Bodin and Prell, 2011b). Chapter 1 already highlighted that regional SESs have become to be managed through a wide variety of governance arrangements. State and non-state actors are operative as partners, contenders or sometimes subordinates to each other. Employing a SNA in circumstances where actors and boundaries are not clearly defined can be advantageous because it provides a systematic way for revealing the most critical relational configurations that shape the governance and the management of SESs and the natural resources therein (Bodin and Crona, 2009). This enables researchers to test and question prevailing assumptions about governance arrangements. It can also provide answers to questions of how and where to intervene in the system to improve existing arrangements (Prell et al., 2008; Stein, 2010).

In recent years, researchers concerned with the management of SESs have started to employ SNA analyses to better understand the impact of different governance arrangements (including network-like arrangements such as co-management) on resource management (Bodin and Prell, 2011b and case studies therein; Hirschi et al., 2010, Rathwell and Peterson, 2012; Vance-Borland and Holley, 2011 etc.). These studies have helped to create more knowledge on the positive and negative impacts of the structural characteristics of social networks on the management of SESs. Or, in other words, by mapping and analyzing the relations between the actors involved in the management of

specific SESs the researchers were able to show whether or not specific social processes important for the management of SESs, such as the development of common rules or the sharing of new and important knowledge, were happening. Figure 3-2 illustrates the relationship between network characteristics and properties, social processes, and governance outcomes as perceived in this thesis. Network characteristics are, for example, cohesion or heterogeneity. Network properties are, among others, density or centralization. Social processes include learning which may be based on other social processes such as information sharing, negotiation or knowledge generation. Governance outcomes could be a management plan, but also a well-maintained river system.

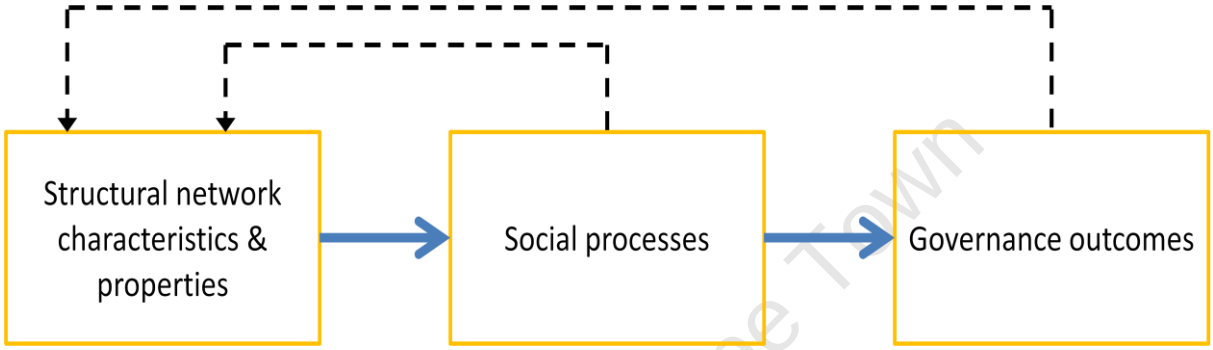

Figure 3-2:The influence of network structure on social processes that determine governance outcomes. Arrows indicate the direction of influence.

3.1.3. Network properties and their impacts on learning and collective action

The conceptual design presented in Chapter 2 has highlighted two social processes: learning and collaboration (expressed here through collective action) as important features of AM. To be able to investigate how actor relations within the network impact collective action and learning and subsequent governance outcomes (such as responses to degrading water quality), several network properties that are understood as being influential with regard to the realization of collective action and learning processes are highlighted in Table 3-1 below. The table is based on the review of previous SNA studies in natural resource management and shows common assumptions that are associated with specific network properties. Whereas some of the measures relate to the whole network, others focus on sub-group or actor level.

Table 3-1: Presumed impacts of network properties on learning and collective action.

(+) indicates a positive relationship, (-) indicates a negative relationship

NETWORK LEVEL	NETWORK PROPERTIES	LEARNING	COLLECTIVE ACTION	MEASUREMENT
Network or group level	**Strong ties**	(+) Transfer of tacit and complex knowledge (-) Circulation of redundant information	(+) Deliberation (+) Trust (+) Prioritization	Strength of relation
	Weak ties	(+) Mobilization of different kinds of knowledge (+) Facilitates innovation (+) Information transmission over long distances (-) Complex tasks	(+) Facilitation of coordination and cooperation among sub-groups	Strength of relation
	Centralized networks	(-) Inability to solve complex problems because of reduced access to diverse knowledge sources	(+) Prioritization and coordination of actions (+) Simple problem solving (-) Legitimacy (-) Representation	Variability in centrality amongst network members
	Cohesive Sub-groups (network modularity)	(+) Knowledge generation (i.e. many knowledge sources) (+) problem solving	(-) Negative impact on collaboration because of likely 'us versus them' attitude (-) Trust	Distribution of ties
	Network density (high score)	(-) Homogenization of knowledge (+) Information transmission	(+) The more relational ties btw. actors of a different kind the greater potential for collective action (+) Deliberation (+) Trust	Number of existing ties divided by the number of possible ties
	Homophily	(+) Communication of complex information (-) Knowledge generation and complex problem solving	(+) Conflict resolution	Shared attributes among actors

Actor level	**Degree centrality** (high score)	(+) Information diffusion in the network	(+) Mobilizing the network because of strong influence over other actors (+) Leadership	Number of ties actors possess
	Betweenness centrality (high score)	Access to a diversity of knowledge ➔ holistic view	(+) Ability to influence flow of resources in the network (+) Actor performs the role of a broker (i.e. linking disconnected groups/ actors)	Number of times an actor sits on the path between two other actors that would otherwise be disconnected

Sources: Bodin and Crona, 2009; Bodin et al., 2006; Ernstson et al., 2008 ; Newig et al., 2010; Prell et al., 2010; Prell et al., 2008.

Table 3-1 and empirical evidence from other studies indicate that there is a need to balance different structural properties in order to support AM (Bodin et al., 2006; Ernstson et al.,2008; Bodin and Crona, 2009; Bodin and Prell, 2011a). Different network properties will enhance particular social processes while, at the same time, inhibiting others. Bodin et al. (2006) provide the example of centrality within a network. While high centrality is good for the effective coordination of actors it may restrict learning and innovation within the network because the communication flow is channeled through the central actor and direct information exchange among most actors remain limited. Furthermore, when some properties become too dominant they actually can start to inhibit the very processes they intended to support. If density, for example, in a network becomes too high then this might lead to the homogenization of experience, knowledge, and attitudes in the network and reduces the ability to detect and respond to changes in the system (Bodin and Crona, 2009). Some studies even suggest that different, sometimes seemingly opposing, characteristics are important for different phases in a management or governance cycle. (Hirschi, 2010; Ernstson, 2008). In other words, there is no ideal network structure that can cater to all circumstances and all management phases (Bodin et al. 2006; Bodin and Crona, 2009).

3.1.4. Linking network heterogeneity and network cohesion to the concept of horizontal cooperation

The previous section highlighted that it would be too simplistic if an analysis singled out individual network properties that may enhance social processes such as learning and collective action. Network properties interact, reinforce, or obstruct one another, and their interplay is influenced by the socio-ecological context in which they are embedded (Bodin and Prell, 2011). To be able to capture the interaction of the different network properties within a particular network and how these properties jointly impact learning and collective action among network members, the two

broader network characteristics of heterogeneity and cohesion are brought into focus[39]. Detailed definitions and explanations of the two terms are provided in the subsequent sections.

3.1.4.1. Rationale for heterogeneity and cohesion

The choice to focus on heterogeneity and cohesion was influenced by the following three reasons. Firstly, both the conceptual design of this thesis as well as the studies mentioned above indicate that for an actor network to be able to utilize its learning and collective action capacities, some degree of integration and coherence (i.e. cohesion) and enough heterogeneity and openness for the inclusion of different types of knowledge in the network structure is required. Secondly, cohesion and heterogeneity can serve as indicators for horizontal cooperation. Indeed, their joint investigation will provide a more comprehensive picture of horizontal cooperation. As already mentioned in the conceptual design it is assumed in this study that one of the main functions of horizontal cooperation is to facilitate the co-production of services for public benefit. This necessitates even in complex governance arrangements social coordination as well as a certain degree of coherence among interacting governance modes. To achieve social coordination through any type of governance arrangement requires cohesion. Cohesion is especially important for dealing with internal conflicts as well as for mobilizing and coordinating collective action (Sandström and Rova, 2010b). Heterogeneity on the other hand is critical for dealing effectively with factors impacting the SES (e.g., it enables the detection of problems in the system and provides access to important resources such as skills, funding, and knowledge to respond to emerging problems) (Sandström and Rova, 2010a). Access to various resources, knowledge sources, and decision-making processes provides flexibility and the capability to adapt to changing or new circumstances (Folke et al., 2005). In other words, exploring how those characteristics are realized and balanced in the network and through which network properties helps to better understand the nature of horizontal cooperation in the network. Thirdly, Chapter 2 highlighted the role of cross-boundary linkages for achieving AM. The argument put forward here is that cross-boundary linkages assist in balancing the network characteristics of cohesion and heterogeneity.

3.1.4.2. Defining and measuring heterogeneity and cohesion

Researchers such as Sandström and Carlsson (2008, 2010) have utilized the two network characteristics, cohesion and heterogeneity, in previous studies to demonstrate how they affect adaptability in co-management systems. This thesis builds on their theoretical understandings[40] and

[39] In this study the term network cohesion instead of network closure is used. Both express the idea of connectedness among a set of actors.

[40] The theoretical understanding is based on Burt's notion of social capital, which he has expressed through the concepts of "social capital as structural holes" and "social capital as network closure"(Burt, 1997, 2000 and

some of their measurements. For example, their proposed hypothesis that networks consisting of a heterogeneous set of actors that are centrally and densely integrated facilitate AM processes has guided in parts the analytical framework proposed in this chapter.

However, this thesis differentiates itself from the previous studies in the following ways. Sandström and colleagues have mainly focused on rule-making processes in their respective studies. This thesis, because of its focus on horizontal cooperation at the operational level, is primarily concerned with the implementation process and day-to-day management activities. In this type of context, the possibilities for achieving the required connectedness and integration in the network through a central coordinating actor is rather limited as too many semi-autonomous actors are involved in the various management functions. It is assumed in this thesis that it is not only a few central actors that can provide for the cohesion in a network but that cohesion may also be achieved through actors that occupy bridging positions in the network and use this position to enhance coordination and learning in the network. In other words, a network that consists of several groups in which a certain level of connectedness among them is provided by bridging actors may exhibit the necessary cohesion for the coordination of action and for trust to develop in order to engage in collective action.

In Figure 3-3, heterogeneity and cohesion are viewed as indicators of horizontal cooperation, and their relationship to collective action and learning is shown. The Figure implies that network heterogeneity facilitates access to different types of knowledge and resources. Network cohesion supports the ability to mobilize these resources, to set common rules of engagement and to manage the SES jointly. For the purpose of this study learning is more associated with heterogeneity (especially integration of different knowledge sources) and collective action with cohesion (especially with the prioritization of activities, the pooling of resources, and the uptake of management functions that go beyond self-interest and/or mandate). However, cohesion influences, to a certain extent, the learning process, and heterogeneity allows for more choices regarding collective action (e.g., the acquisition of more appropriate resources).

2003). It also is closely related to the notion of bonding and bridging ties (Granovetter, 1973; Bodin and Crona, 2009; Sandström and Rova, 2010a).

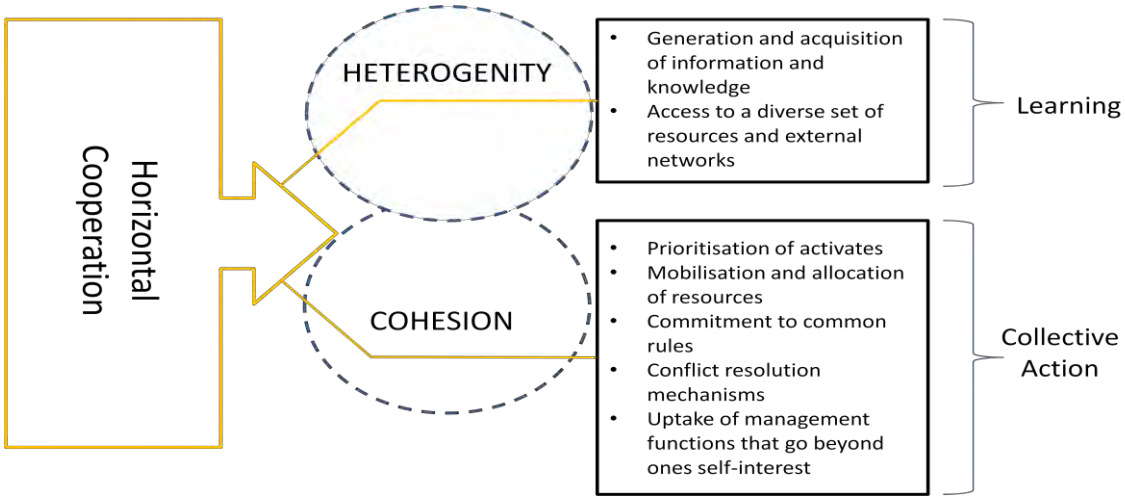

Figure 3-3: Heterogeneity and cohesion as important indicators of horizontal cooperation influencing learning and collective action

For investigating horizontal cooperation at the operational level through an analysis of network cohesion and heterogeneity, the following social network measures have been combined: density and centralization measures are used for assessing the cohesion in the network. To gain a more accurate picture of the cohesion in the actor network several other measures such as degree centralization and a sub-group analysis were carried out. Heterogeneity is measured by combining attribute data (actor diversity) and cross-boundary linkages (i.e. measurement of interactions among sub-populations of the network defined by specified actor attributes). Degree and betweenness centrality were the primary measures to locate central actors[41] in the network. Other potentially influential actors, i.e., those critical with regard to cross-boundary linkages, were identified via the G-F brokerage method (Gould and Fernandez, 1989). Figure 3-4 provides an overview of all relevant network measures and how they assist in assessing cohesion and heterogeneity in the actor network.

[41] Central actors are those that either are connected to many others in the network or are connected to many other organizations that otherwise would be unconnected. Central actors have often more advantage as they can control information, have easy access to resources available through the network and can influence others in the network.

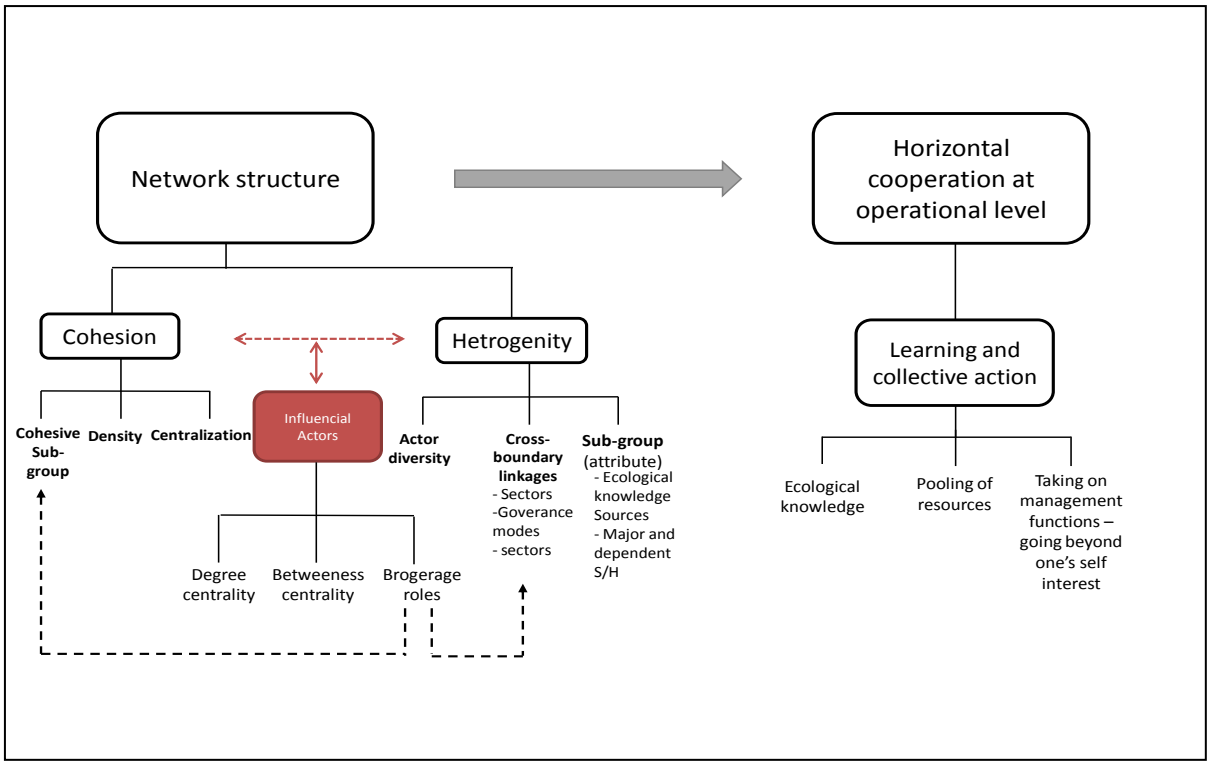

Figure 3-4: Overview of the social network measures used for analyzing cohesion and heterogeneity.

Network cohesion

A cohesive network can be described as a well-connected network in which all actors are closely linked to each other either through many direct (and strong) ties or indirectly through central coordinating actor(s) (Borgatti et al., 2013; Sandström and Rova, 2010b). In other words, high levels of interconnectedness characterize cohesive networks.[42] It has been argued that actors that are part of a cohesive network are more likely to establish common values and norms, monitor each other, and to develop trust relations (e.g., Carlsson and Sandström, 2008). For example, Hirschi (2010:9) writes, "[f]rom a perspective of network theory, strengthened cohesion among the relevant actors in a region… [fosters] a normative environment that facilitates cooperation across different societal sectors with diverging interests and objectives." Similarly, Sandström and Rova (2010b) argue that well integrated networks facilitate the formation of common views regarding the system to be managed as well as the specific problem definition. Features that are strongly dependent on cohesion such as trust, common problem definition, and goal setting are critical for collective action (Ostrom 1990; Ansell and Gash 2007). Indeed, Sandström and Rova (2010b) argue that cohesion has been positively related to collective action.

[42] In some studies the term network cohesion has been equated with the term network closure (see for example Sandström and Rova , 2008 or Sandström, 2011). For the purpose of consistency the term cohesion is used in this study.

Network cohesion is assessed in this thesis by combining density measures with centralization measures. These measures are commonly used among network analysts for measuring cohesion (see for example Hirschi 2010; Stein et al., 2011; Carcamo et al., 2014). Network "centralization measures the extent to which ties hover around one actor, [network] density measures the extent to which all ties are actually present" (Prell, 2011: 170). In other words, whereas density focuses on the number of ties present, centralization looks at tie distribution. This provides a good understanding of whether the interconnectedness in an actor network is reliant upon a few central actors. A more detailed description of the measures and why they were combined is provided in the discussion below.

Network density

Density provides a good account of the extent to which all actors in the network are linked to each other. In other words, density gives information on the overall activity in a network (Prell, 2012; Borgatti et al., 2013). Network analysts argue that many ties between actors promote collaboration because they strengthen trust and reciprocity as well as decrease the risks and costs of collaboration (Bodin et al., 2006; Sandström, 2011). It has also been hypothesized that the higher the density in a network the greater is the potential for collective action (Burt 2003; Bodin and Crona, 2009). A network in which many actors are directly connected facilitates the development, and compliance with, mutual norms and increased information and knowledge dissemination. However, as mentioned in Section 3.1.1, too much density can potentially lead to the homogenization of knowledge and information (Bodin and Crona, 2009).

Prell (2012:167) states that density "counts how many actual ties exist in a network, and expresses this number as proportion of the potential ties that could exist in the network". In other words, network density can be measured by dividing the number of existing ties by the number of possible ties (Scott 2000; Bodin and Crona, 2009). A network in which all actors are directly linked to each other has a density of one. A network in with a density score of 0.25 means that 25% of all possible ties are present.[43]

For the analysis of the Berg management network, density measures were used to:

a. establish the level of activity within the network [whole network density];
b. compare the level of interaction among the organizations with regard to information exchange and collaboration [whole network density];

[43] It is important to note that the number of possible ties in a network with symmetric ties differs from those with directed ties. The former is calculated by n (n-1)/2 (with n being the total number of actors) the latter is n(n-1).

c. compare the interaction within and between groups of actors identified by specific actor attributes (e.g., core WMOs) or relational groups (e.g., collaborative clusters) [group density].

In order to accurately interpret the density in a network and to draw conclusions about its cohesion, it is vital to consider the size of the network, whether the network is organized in segmented sub-groups, as well as what the level of network centralization might be (Prell, 2012).[44] All of these factors impact density (see for example Scott, 2000; Borgatti et al., 2013). If a network consists of various sub-groups it is not enough to examine whether sub-groups are present but also the level of fragmentation in the network caused by the sub-groups. The possibility of the existence of a sub-group structure was investigated in this study by using the Girvan-Newman algorithm in NetDraw (Borgatti, 2002) and UNCINET (Borgatti et al., 2002). A more detailed discussion on sub-group analyses in this study is provided in Section 3.1.4. Network density measures were further complemented with degree centralization measures based on degree centrality scores of the individual actors.

Network centralization

As mentioned earlier, network centralization gives an indication of the extent to which ties concentrate around particular actor(s) (Scott, 2000; Borgatti et al., 2013).[45] Any measure of graph centralization, whether it is based on degree, betweenness, or closeness centrality, looks at the differences between the centrality scores of the most central actor and those of all other actors (Scott, 2000). That is, as a first step, the actor centrality of each actor is determined and then the differences between each actor centrality score and the centrality of the most central actor are compared (Borgatti et. al., 2013; Freemann 1979).

Sandström and Rova (2010a) state that degree centralization depicts the level of hierarchy within networks. The higher the centralization score the more centralized the network. For example, a centralization score of 1 implies that all ties are centered around one actor. This is represented through a star-like network graph. A centralization score of 0 means that all actors are equally connected to each other. This is represented through a circle-shaped network graph.

[44] Friedkin (1981) for example, emphasises that density is not a good indicator for cohesion in network where many cohesive sub-groups exists. These groups have a high level of interconnectedness among their members, yet they may have few links among each other leading to a rather fragmented network.

[45] To clarify the difference between centrality and centralization, Scott (2000) makes a useful distinction. He states that the term centrality should be confined to the idea of point centrality (i.e. actor level). Centralization on the other hand "refers not to the relative prominence of points [i.e. actors] but to the overall cohesion and integration of the graph" (Scott, 2000:82). In other words, centralization is a network level concept and centrality is a measure of focusing on the actor level (Wasserman and Faust, 1994).

Sandström and Rova (2010a) argue in their study that high network centralization is an indicator of network closure (i.e., high network cohesion). Yet, others, such as Prell (2012), do not necessarily associate a high centralization score with a network that is cohesive. Prell uses the example of two networks that have the same density score but in which one has a high centralization score in comparison to the other. Prell points out that the network with the lower centralization score may actually be the more cohesive network as the ties are more evenly distributed. This shows that one cannot easily jump to conclusions. Rather, it is important to look at the various measures jointly, as well as integrate information generated from the qualitative data of the network. To enhance the analysis of the cohesion within the Berg management network, the maximum distance (diameter [46]) between any two organizations as well as the average steps between any two actors (average path length) were calculated. A relatively small diameter as well as short average path length means that all the actors in the network are in close proximity to one another. Hence, it does not take much time for information to travel from one specific actor to another. The final interpretation of the density and centralization scores was guided by the qualitative understanding of the network derived from interviews and participant observation and by considering network density jointly with other network measurements.

Network heterogeneity

Borrowing from Sandström and Rova, (2010a: 14) a heterogeneous network is defined here as a network "that is comprised of a rich diversity of different types of actors involved in extensive cross-border collaboration".[47] The concept is therefore concerned with the range of actors involved and the resource exchange among them (Sandström and Rova, 2010b). By looking at the diversity of actors involved in the network, the researcher can get a first impression of the potential resources available to the network as it reflects the different resources, types of knowledge and skills that the different actors can contribute to the network. In other words, a network composed of a diverse set of actors could increase management performance as it ultimately enhances the acquisition of relevant resources (Sandström and Rova, 2010b).[48] The actors may possess important resources themselves or access them through their linkages to groups or networks outside of the Berg management network. Finally, heterogeneity is also understood as being critical for the development

[46] Diameter is the longest geodesic (geodesic refers to the shortest path between two actors) in the network. (Hanneman and Riddle, 2005).

[47] This definition builds also on Reagans and Zuckerman (2001) as well as Carlsson and Sandström (2008).

[48] When assessing the heterogeneity of the network it is important to keep in mind the specific research context. In circumstances where only few and highly similar users and managers exist one cannot expect that the network will comprise a highly diverse actor set. Therefore the assumption here is that the network should at least match the diversity of users.

of new ideas and innovative solutions and enhanced knowledge generation (Burt, 1992; Sandström, 2008).

Yet, just having different kinds of actors involved does not necessarily mean that these actors exchange resources, information and knowledge with each other (Sandström and Rova, 2010b). It is important to investigate the linkages between the different kinds of actor as this may provide a more accurate indication to what extent existing resources are actually available to the network. Hence, it is the level of cross-boundary interaction that needs to be measured in order to establish an adequate understanding of the heterogeneity in a network.

Actor diversity and cross-boundary linkages

Similar to Sandstöm and Rova (2010b), actor attributes from the organizations were used in this study to assess the cross-boundary interactions among the actors involved in the Berg management network. Broadly speaking actor diversity can be assessed by counting the number of actors representing different stakeholder groups or other forms of relevant categorization (Sandstöm and Rova, 2010b). Hence, this is a non-structural measure based on attribute data.

One way for assessing cross-boundary linkages can by examining the proportion of ties that connects actors from specified categories (Sandstöm and Rova, 2010b). However, it is important to note that cross-boundary linkages can be defined in various ways. In the context of AM three types of cross-boundary linkages became the focus of the investigation of heterogeneity in this thesis:

i. Linkages across governance modes and linkages across sectors (E-I Index);
ii. Linkages between actors that are ecological knowledge sources and those that are not;
iii. Linkages and integration of major water users and 'dependent' stakeholders (core-periphery analysis discussed in section).

Cross-boundary linkages: modes and sectors

The definition of horizontal cooperation advanced in this thesis makes specific reference to sectoral integration and coherence of governance modes. That is, the level of interaction of actors across sectors and modes of governance provides a good indication on the level of horizontal cooperation. The assumption is that a high level of collaborative interaction between the different sectors may indicate that conflicts of interest (e.g., competing demands, differing sectoral goals and needs) are effectively negotiated among the organizations. A high level of collaborative interaction between organizations from different modes of governance, on the other hand, may signal a certain level of coherence across the modes. It may for, example, be indicated that incentive structures provided by the different modes complement each other (e.g., supply chain farm audits and government legislation targeting both sustainable land management practices). Furthermore, a high level of

cross-boundary linkages (for sectors and modes) implies that the heterogeneity of the network is effectively utilized and one may speak of a level of horizontal cooperation that allows for the effective co-production of services for public benefit. UCINET has a function called the E-I Index which enables the researcher to measure and compare inter-sectoral and intra-sectoral interaction as well as inter-mode and intra-mode interaction.

The External- Internal (E-I) index

The E-I index was developed by Krackhardt and Stern (1988) to compare the number of ties within groups and among groups. Hanneman and Riddle (2005) state that the index "takes the number of ties of group members to outsiders, subtracts the number of ties to other group members, and divides by the total number of ties". The index has a range from 1 to -1. A value of 1 means that all ties are directed towards other groups (external) a value of -1 means all ties are within the group (internal). (Krackhardt an Stern, 1988). The E-I Index function in UCINET (Borgatti et al., 2002) also includes a permutation test which assesses the extent to which the observed values differ from the expected values based on a random distribution of ties (Everett and Borgatti, 2012). For the analysis of the cross-boundary linkages in the Berg management network, a 5000 iteration permutation test was done which created a sample to measure significance against. This provided an understanding of whether the observed result can be seen as significant and did not just happen by chance alone.[49]

The E-I Index can be measured at three levels: for the whole network (i.e., percentage of ties that are cross-boundary linkages), at the group level (number of cross-boundary ties for each group has and number of intra-group ties), and at the individual level (i.e., how many ties a specific actor has to other members from his own group and how many he has to non-group members) (Everett and Borgatti, 2012; Hanneman and Riddle, 2005). The information gained at the group level helps in understanding the extent to which specific groups are involved in collaborative (cross-boundary) linkages and at the individual level it shows the extent to which an actor is embedded in his own group. For the purpose of this study the E-I index has been considered for the network and group level. The role of individuals in the cross-boundary linkages is further explored with help of the G-F brokerage method (Section 3.1.5) which provides more specific information on which groups the actor links.

3.1.5. Sub-group Analyses

For the reason that sub-group analyses play an important role for examining heterogeneity and cohesion in the network (see Table 3-2), sub-groups are discussed as a separate item in this section.

[49] In the permutation procedure the blocked groups are maintained as well as the overall density of ties what changes is how the ties are distributed (Hanneman and Riddle, 2005).

Sub-groups, which broadly speaking are sub-populations of the network, are of significance in a network analysis in several ways. For example the organization of the network into sub-groups based on attribute data (e.g., sector, type of resource users, locality etc.) helps to explore the relationships between and within specific stakeholder groups or how specific actor attributes have affected the structuring of the network. At the same time, social network analysts may decide to identify and define sub-groups from a purely relational perspective. Hence, the focus is on ties between pairs of actors (Wasserman and Faust, 1994). These types of sub-groups are called cohesive sub-groups. A cohesive sub-group is referred to as a sub-set of actors who distinguish themselves from other actors of the network in that they share many, strong mutual, direct ties (Wassermann and Faust, 1994). In other words, they form relational clusters in the network. Given the strong patterns of interaction between members of a cohesive sub-group they tend to share similar perspectives values and interests (Collins, 1988). They also tend to create a group identify based on implicit knowledge and understanding among the group members, and which may not be easily be understandable to actors outside the group (Bodin and Crona, 2009).

In this study, the sub-group analyses helped in interpreting the cohesion and heterogeneity in the network (see Table 3-2). For both network characteristics the existence of cohesive sub-groups as well as sub-groups defined by attribute data were examined. The reader is referred to Chapter 5 for detailed explanation how and for what purposes subgroups based on attribute data where examined for the Berg management network.

Table 3-2: Overview of sub-group analyses

Type of sub-group	Cohesion	Heterogeneity
Sub-groups based on attribute	• core water management organizations (WMOs) vs. non-core WMOs	• Ecological knowledge sources • Sub-groups belonging to a specific sector • Sub-groups belonging to a specific governance mode
Cohesive sub-group	Girvan-Newman algorithm ⇨ Identifying collaborative clusters	Core–periphery analysis ⇨ Integration of major water users and dependent stakeholders

Cohesive sub-group analyses

As mentioned earlier, a cohesive sub-group analysis is important for being able to make an informed judgment about the cohesion of the overall network. Several methods exist for identifying cohesive sub-groups (for an overview see Borgatti et al., 2013 or Hanneman and Riddle, 2005). While the methods use different approaches, all of these approaches are concerned with the identification of sub-sets of actors that can be distinguished from the rest of the network because of the cohesiveness or reachability among the actors and/ or because of the frequency of interaction. To identify and

verify the existence of cohesive sub-groups, it is recommended that several different sub-group methods be used to see if they perhaps indicate similar results (Borgatti et al., 2013).

In the context of this thesis a cohesive sub-group analysis was utilized to detect self-organized collaborative efforts (i.e. instances of collective action) through which management issues (e.g., degrading water quality) are being addressed. This was done with the Girvan-Newman algorithm. Another type of sub-group analysis (the core-periphery analysis) was conducted to identify marginalized actors in the network and to investigate how this affects the heterogeneity of the network. Both algorithms are discussed.

Girvan-Newman algorithm (Girvan and Newman, 2002)

The primary method used for identifying cohesive sub-groups in this study is the Girvan-Newman (G-N) algorithm. While other methods (such as clique analysis or k-core) are good for identifying strongly linked cores of communities, these methods tend to overlook the more peripheral actors who may still be part of specific community structures (Newman and Girvan, 2004).[50] The G-N algorithm addresses this issue. The algorithm is therefore relevant for this thesis since it is interested in identifying self-organized collaborative efforts among a diverse set of organizations which do not necessary represent closely-knit identity groups.[51]

The focus of the G-N algorithm is on fragmentation rather than the interconnectedness upon which most of the other sub-group analyses are based. The algorithm identifies the weak spots in the network by calculating the edge betweenness of the network ties. In other words, through an iterative procedure the ties (edges) that cause the highest fragmentation in the network are removed (i.e. edges with the highest edge betweenness score).[52] After the removal of the edge with the highest betweenness score, the edge betweenness is recalculated until only isolates (i.e. unconnected actors) make up the network.

[50] Newman and Girvan (2002:1) define community structures as "groups within which the network connections are dense but between which they are sparser". While the definition is similar to that of cohesive sub-groups, the term community implies already less stringent conditions.

[51] From the qualitative understanding of the Berg management network, it was expected that, among those involved in the management of the catchment area, many sub-groups with very strong ties will be identified (i.e. bonding ties). As mentioned earlier, bonding ties are critical for the development of group identity (e.g., sharing of similar views and values) and through them actors can exert strong influence on one another.

[52] Edge betweenness counts the number of times an edge (tie) lies on the shortest path (geodesic) between two pairs of nodes (Borgatti et al., 2013). In this study, the geodesic (i.e. shortest path length) was used for calculating the edge betweenness.

The procedure proposes several possible partitions; i.e. hierarchical nested group levels from which the researcher can chose. To make a choice about the most appropriate partition for the network, the researcher can use the Q-value. The Q-value is a score that is provided for each partition and which assesses the modularity of the partition (i.e. quality of a particular division) (Borgatti et al 2013). Newman (2006:8578) defines modularity as "the number of edges falling within groups minus the expected number in an equivalent network with edges placed at random". NetDraw (Borgatti, 2002) has a function which automatically provides the Q-value for each calculated partition. The Q value can be negative or positive. Positive values, especially with a high value (maximum is Q =1) indicate the possibility of a community structure (Newman, 2006).

Core-periphery analysis

A core-periphery analysis was undertaken to assess the integration of major water user and 'dependent' stakeholders in the network. The aim was to get a better sense of how well heterogeneity is utilized in the network. The assumption is that it is not enough for major water users and 'dependent' stakeholders to be part of the network but they should be well integrated i.e. form part of the core. For organizations that form only part of the periphery it might be more challenging to ensure that their interests and needs are considered in the decision-making processes of the management network.

This method divides the network into two groups the core (which should be understood as a single cohesive sub-group) and a periphery (a group of actors that don't form a cohesive sub-group but which are a loosely connected to the core). In networks in which a core-periphery structure can be observed, actors can be divided into two groups, one being the core and the other the periphery. Actors belonging to the core are densely connected to each other and occupy central positions in the network (Borgatti and Everett, 1999). Hence, they form one single cohesive sub-group. The actors from the core obtain their central positions from the connections among themselves as well as from having connection to actors from the periphery. The periphery contains actors that are sparsely connected in the network (Borgatti and Everett, 1999).[53] Hence, peripheral actors do not form a cohesive sub-group. It is assumed that in networks with pronounced core-periphery structures, important resources are concentrated in the core, i.e. it is primarily the core actors that have access to the resources (Borgatti et al., 2013). In comparison, actors from the periphery depend on the core to assure that their interests are considered and that they gain access to specific resources provided

[53] An idealized core-periphery structure consists of few core actors that have dense relations to each other, while actors in the periphery do not have relations to each other but some actors from the periphery have an outgoing relation to actors from the core. (Prell, 2012).

by the network. Hence, core-periphery structures affect knowledge and information acquisition as well as resource distribution in the network (Crona and Bodin, 2009). In UCINET the core-periphery continuous function was chosen over the discrete function because it is more applicable for symmetric data and it provides richer information on the embeddedness of the individual actors (Borgatti et al., 2013).

3.1.6. Influential actors effect on the network: actor centrality and brokerage positions

Some of the previous sections suggest that that the two network characteristics, cohesion and heterogeneity, need to be well balanced to contribute to AM. A high level of heterogeneity that is not accompanied by a certain level of connectedness in the actor network will obstruct the development of a shared understanding of the management issue at hand as well as the integration of the available knowledge. Furthermore, the prioritization and coordination of collective action is highly unlikely within a diverse set of actors who are scarcely connected. On the other hand, too much cohesion can lead to homogenization, with knowledge and information becoming redundant. Nevertheless, a balance between cohesion and heterogeneity does not occur on its own. It often requires some steering. In this context, it needs to be pointed out that some actors in the network, because of how they are positioned in the network, have a significant influence on the network and its working. These actors can, because of the way they are linked to other actors, exert influence on other actors and the network as a whole (e.g. they are able to spread their ideas and/ or control the information flow of information within the network) (Bodin and Crona, 2008). Such actors have therefore a higher potential to navigate between network heterogeneity and cohesion; i.e. integrate new knowledge or mobilize collective action. Yet, as the discussion below demonstrates, which actor occupies an influential position in terms of enhancing heterogeneity and or cohesion is not a straight forward matter but must be considered in relation to the specific research context.

After a brief description of who qualifies as an influential actor from the network perspective, several measures are proposed to identify influential actors in the context of enhancing heterogeneity and/or cohesion. This serves as basis for exploring how these actors utilize their positions (e.g. have actors connecting sub-groups, the willingness, capacity, and motivations to coordinate sub-group activities towards a common goal).

Structural positions, social roles & agency

Hanneman and Riddle (2005) state that actors that occupy a favorable position are embedded in the network in ways that provide them with more opportunities and fewer constraints in comparison to other actors of the network. The authors continue to say that “[h]aving a favored position means that an actor may extract better bargains in exchanges, have greater influence, and that the actor will be a focus for deference and attention from those in less favored positions” (Hanneman and

Riddle, 2005 Chapt.10). However, it is important to keep in mind that while an influential actor, by redirecting specific resources in the network (including connecting other actors or bringing in new information) can shape part of the network, he or she cannot influence all relations (Ernstson et al., 2008). This goes back to the notion that it is "neither isolated individuals (e.g. rational self-interested individuals) nor organic wholes, but related individuals who collectively give rise to emergent properties or qualitative novelty, above all, social structure." (Bodin et al., 2011:8, referencing Emirbayer (1997)).

Several measures exist to describe in greater detail the participation of different actors in the network and their influence in the network. The most common actor level concept used in whole network analyses to identify key actors (i.e. potential leaders) is that of centrality (Freeman, 1979; Prell, 2011). The concept of centrality has been related to ideas of importance, power, and prestige (Wasserman and Faust, 1994; Borgatti, and Everett, 2006). In network language, favorable positions may be occupied by actors who:

a) connect other actors in the network who otherwise would not be connected (betweenness centrality);
b) have many direct ties to others (degree centrality);
c) have direct ties to actors that are themselves well connected in the network (eigenvector centrality); or
d) are within close proximity to many others (closeness centrality).

To summarize, all of these positions provide actors with an advantage with regard to the resources, information and opportunities that may be available in the network.

Before discussing which of these centrality measures are utilized in this study, it is helpful to briefly discuss the notion of agency and the interplay of structural position, personality traits, and/or organizational characteristics. Bodin and Crona (2008) convincingly argue that agency[54] is a result of the personal characteristics of the actor as well as his or her structural position in the network. When, as in this study, the actor is a collective entity such as an organization rather than an individual it seems to be important to also consider organizational characteristics (e.g. mandate, size, level of formality). The assumption here is that it is not only the actor's network position but also the characteristics of the organization that the individual person represents that constrain him or her in

[54]Bodin and Crona (2008:2764) state that agency, in particular enabling agency, is realized through "leaders or influential actors, who activate a potentially latent stock of social capital and use it to produce a flow of benefit."

exercising his or her personality traits[55] (see Figure 3-5). The reason why personality traits matter is because, although individuals are constrained by their organizational affiliation, they still have some leverage to use their personal skills that allows them to utilize the position they occupy (e.g. there might be flexibility in interpreting the organizational mandate or which knowledge sources are viewed as legitimate). The argument put forward is that if one wants understand how influential actors utilize their positions in the network these elements need to be considered.

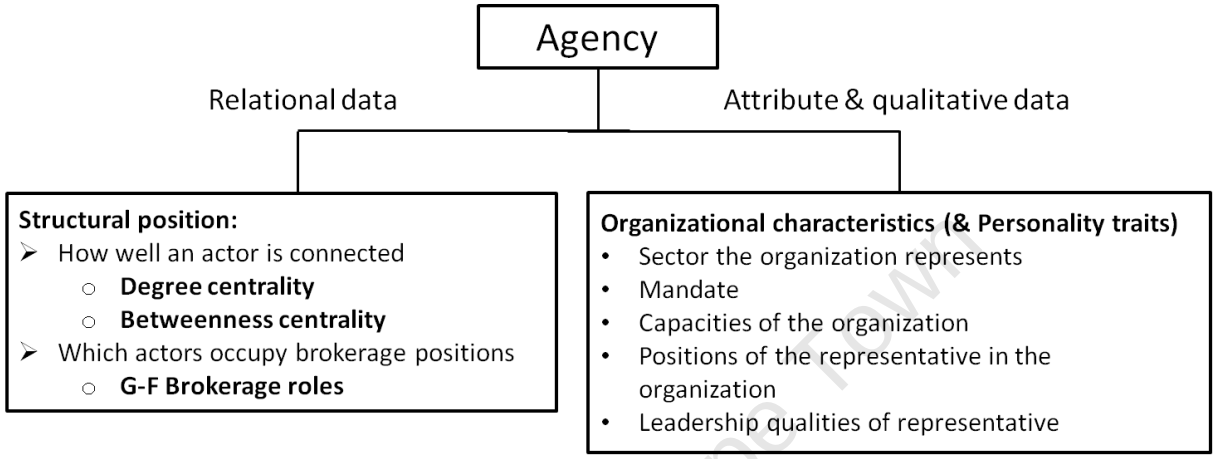

Figure 3-5: Depiction of Agency: structural position and organizational/ personality traits.

Identifying influential actors: centrality measures and G-F Brokerage roles

Betweenness centrality and degree centrality were chosen in this study for identifying central actors. The G-F Brokerage method has been employed to identify actors that bridge between groups of actors that have either been defined by attribute or relational data.

Degree centrality

Degree centrality simply counts the number of direct ties an actor has. This in turn shows how active a specific actor in the network is.[56] Those actors that have many direct ties to others (i.e. a high degree centrality) are seen as very involved in the network (e.g. Prell, 2012). Network analysts have shown that the more ties an actor has the more opportunities there are because of the many alternative options. Such actors depend, for example, less on individual actors for resources and information (Hanneman and Riddle, 2005). Being well informed about the activities in the network, these actors are particularly suitable for coordinating actions in the network. Yet, actors that are directly connected to many others may actually be limited in their capacity to influence these actors.

[55] Personality traits are viewed here very broadly as human capital which includes the educational background of a person as well as leadership skills.

[56] Degree centrality does not take into consideration the other actors and their ties in the network. It focuses only on the immediate ties of the actor. It is therefore understood as the most local centrality measure (Borgatti et al., 2013).

Given the sheer number of ties and the associated cost of their maintenance, most of these ties will remain weak (Prell, 2012).

Betweenness centrality

An actor with a high betweenness centrality sits on many occasions between two other actors that without him would be disconnected (Borgatti et al., 2013). Such an actor gains his influence not from the number of direct contacts to others in the network, but from where he is situated in the network. He can control the information flow between the two actors that he connects by, for example, withholding or distorting information (Prell, 2012). In this way, betweenness centrality provides a picture on who connects different segments of the network and who can potentially control the resource flow in such a way that can either facilitate or block collective action or knowledge generation (Ernstson et al., 2008).

It has been argued that actors occupying such positions have a higher potential then other actors in the network to navigate change (by bringing together different groups for different tasks, etc.) (e.g., Rathwell and Peterson, 2012). They have access to non-redundant information and perhaps more diversified resources. They therefore can either act as gatekeepers or as brokers in the network (Borgatti et al., 2013).57 Bodin et al. (2006) write that "a broker, merely by its structural position, gains access to many pieces of group specific information captured inside the different groups, which allows the broker to synthesize a large knowledge pool." A gatekeeper is someone that occupies an influential position in the network but who is unaware of or unwilling to utilize the position in ways that can benefit the larger network, e.g. they may deliberately block collective action (Bodin and Crona, 2009). Betweenness centrality is measured by counting how many times an actor sites on the shortest path (the geodesic) between two other actors (Prell, 2011).

Identifying brokers: G-F Brokerage roles

Gould and Fernandez (1989) developed a useful method at the individual level which examines the extent to which a node (actor) may connect different groups. More specifically, "they consider the relations between triads in which node A has a tie to node B, and B has a tie to node C but has not a tie to A" (Everett and Borgatti, 2012:566). B because it is on the direct path between A and C and is considered to occupy a specific structural position and consequently a social role (namely the broker). Hence, brokerage can be thought of as a situation in which an intermediary actor (the broker)

[57]The terms gatekeeper and broker as described in this sections differ slightly from how these two terms are discussed in the context of the G-F Brokerage role method. In the G-F method, a gatekeeper is part of a specific relational interaction among three actors. Here, the gatekeeper and broker are described in terms of agency is used. A broker has then a more normative connotation, i.e. he uses a network's structural advantage to enhance the social capital and therefore the adaptive capacity of the network as a whole.

facilitates the transaction or resource flow between two other actors which themselves are not connected to each other (Gould and Fernandez, 1989 citing Marsden, 1982). Gould and Fernandez (1989) developed a typology of brokerage.[58] Depending on the group membership of the two actors that the broker connects, the broker may fulfill one of the following 5 brokering roles (Gould and Fernandez, 1989; Hanneman and Riddle, 2005):

- Coordinator: broker connects two members that are part of his own group;
- Gatekeeper: broker connects an outsider (member from another group) to a member from his group;
- Representative: broker connects one member from his group to an member from another group;
- Consultant[59]: the two actors that the broker connects are members of the same group but the broker belongs to a different group;
- Liaison: the broker links two actors from two groups without the broker being affiliated with either of the two groups. Hence, he is member of a third group.

For analyzing brokerage roles, actors need to be partitioned into meaningful groups. In the context of this study, brokerage roles are considered for the investigation of cross-boundary linkages based on sectors and modes of governance, as well as between cohesive sub-groups.

It needs to be noted that groups organized according to sectors and modes are rather arbitrary and may not represent existing 'community' structures in the network. In other words, actors belonging to these groups may not be relationally connected. For example, an actor that brokers between his sector and another sector may have little influence on the other actors belonging to his sector as he may or not have many ties to them. Hence, he may also not necessarily represent their needs or interests. The capacities of these types of 'brokers' in facilitating collaboration across sectors (or governance modes) may therefore be limited. However, these brokers are of interest for this study since they represent organizations that seem to have the necessary capacities to navigate between different modes (or sectors). The situation is slightly different for actors that link across cohesive sub-groups (which because of the extensive level of interaction often represent community structures). These actors tend to be well embedded in their groups and can therefore be important in facilitating the collaboration between the groups

[58] Gould and Fernandez (1989) partitioned the actors into non-overlapping sub-groups and only considered directed relations. While this study is concerned with symmetric (i.e. non-directed) relations, the method is still applicable. The only thing that need to be noted that in a undirected relation only 4 broker roles exists. The gatekeeper and representative are the same because in non-directed relations they express the same role.

[59] Note that Gould and Fernandez (1989) refer to this role as the itinerant broker. Borgatti et al. (2002) refer to the same position in UCINET as consultant. To reduce the confusion the latter is also used in this study.

Part one of this chapter demonstrates why the field of network research (in particular SNA) is most applicable for describing the actor network under consideration and for investigating horizontal cooperation at the operational level. It was further shown that network heterogeneity and cohesion are fitting indicators for investigating horizontal cooperation in the context of the management of SESs. These two network characteristics directly affect learning and collective action, two social processes that were identified in Chapter 2 as being essential features of AM. The quantitative analyses/ measures that are outlined above help to describe the patterns of interactions and show how the resulting network structures has constrained or fostered AM in the Berg catchment.

Despite the advantages offered by a formal quantitative analysis of actor relations for gaining greater clarity on the working of complex governance arrangements, it certainly cannot provide answers to all questions. The qualitative examination of specific collective action initiatives that have emerged in the actor network can provide important insights into the extent of collaboration in the network and its suitability for the realization of adaptive management. It is for this reason that a qualitative investigation into collective action complements the SNA.

3.2. Collective Action

In addition to the formal SNA, horizontal cooperation is further explored in this thesis through the qualitative analysis of collective action initiatives in the Berg catchment. A focus on collective action can provide another insightful perspective on horizontal cooperation. Looking at how existing management challenges are jointly addressed by various actors operative in regional SESs can, for example, illustrate the extent of sectoral integration (i.e. the level of coherence and coordination among the different stakeholder groups), depict the emergence of self-organization, and provide more detailed knowledge about the presence of incentive structures for engaging in joint action.

Another reason as to why collective action is used in this study for assessing horizontal cooperation is that contemporary environmental problems and socio-economic changes require collective action among actors who have competing claims on resources that are becoming scarce (e.g. Poteete and Ostrom, 2004). In other words, collective action will most likely gain in importance as an essential governance mechanism in the management of SESs. Understanding how collective action that transcends various scales and levels is achieved is therefore critical. This is particularly the case for regional SESs where trust and social capital are difficult to establish and where relevant cross-boundary linkages may not be easily recognized and fostered (e.g., Marshall, 2013). The interest of this research in collective action is primarily directed at processes that contribute to the maintenance of key management functions and that help to strengthen collaborative cross-boundary interactions

among the actors, hence, those processes intended to contribute to the co-production of services for public benefit.

3.2.1. Insights from the study of the commons

Collective action has been introduced in Chapter 2 as a specific expression of collaboration. Generally speaking, it refers to a group effort that entails a wide spectrum of possible activities ranging from the coordinating of activities (e.g., development of joint communication tools), resource mobilization (e.g., the pooling of resources or division of tasks), and the development of joint institutions (e.g., rules for resource management) (Poteete and Ostrom, 2004).

In the realm of natural resources management, the common pool resource literature has focused on the emergence of institutions for collective action. Scholars from this field have provided important insights into the nature of collective action problems and highlighted critical variables for explaining successful collective action in local and regional common pool resource systems (see e.g., Ostrom, 1990; Feeny et al., 1990).

Ostrom (2009a) defines collective action problems as situations where it takes the effort of multiple actors to achieve joint outcomes and where some actors may opt for a free-rider strategy as it is difficult to exclude anyone from the benefits of the actions taken by the collective. The likelihood of collective action problems to occurring in regional SESs is quite high. Many resources and services that regional SESs provide, such as catchment areas, are non-exclusive (i.e. it is difficult to exclude actors from the use/ consumption of the resource) and subtractable (i.e. use by one actor reduces the benefits to others), or they are non-exclusive but their consumption does not diminish the benefit to other users. For a long time, based on the Hardin's influential work 'The Tragedy of the Commons' (1968) and Olson's 'The Logic of Collective Action' (1965), it was argued that collective action problems could only effectively be addressed through state control or market regulation (privatization). The argument was based on the assumption that actors are selfish, fully rational individuals and ignored the fact that actors are embedded in pre-existing relationships. However, over the last decades, Ostrom (e.g., 1990, 2005, 2009) and other scholars (e.g. Marshall 2008; Termeer et al., 2013; Sarker et al., 2014) have shown that groups of actors can under certain conditions establish and enforce self-imposed institutions through which they jointly manage their resources sustainably.[60]

[60]Note that Ostrom and her associates did not question the validity of Hardin's and Olson's conclusions, but they questioned the generalization of the 'conventional theory' that developed from these conclusions (Ostrom, 2009 or Wilson et al., 2013). Ostrom showed that user self-governance can be an effective third policy alternative for dealing with collective action problems. However she has repeatedly emphasized that

Before turning to the specific conditions under which actors will replace a free-rider strategy with a strategy of reciprocity, it is important to introduce two other terms: self-governance and self-organization. Kooiman (2003:79) refers to self-governance as "the capacity of social entities to govern themselves". In the context of natural resource management, Ostrom (2005:132) states that self-governance implies that "actors who are major users of the resources are involved in making and adapting rules within collective-choice arenas regarding the inclusion or exclusion of participants, appropriation strategies, obligations of participants, monitoring and sanctioning and conflict resolution". Self-governance is understood in this thesis as sub-set of collective action. It refers to joint actions that have emerged from self-organization and entails the creation of a joint system of rules through which the SES or specific activities related to the SES are managed.

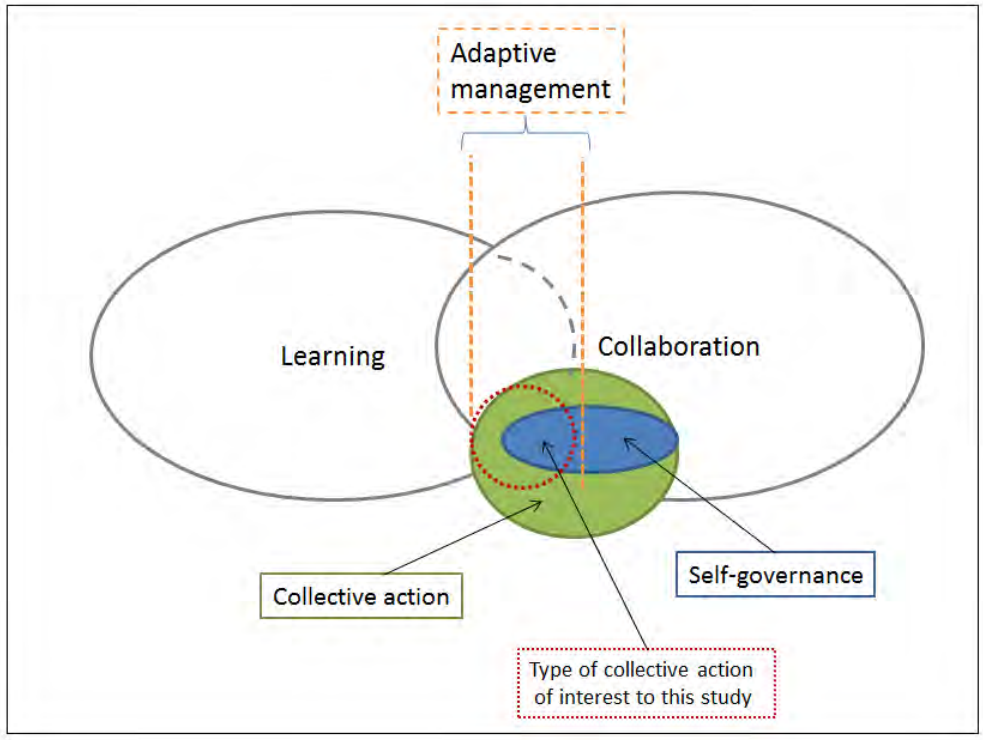

Figure 3-6: Specifying the relationship between collaboration, collective action and self-governance

Self-organization is often discussed in relation to community-driven initiatives through which local stakeholders attempt to manage their resources with a certain level of autonomy. In this thesis a broader notion of community is used. It refers to a set of actors within a regional SES (the Berg catchment) that are not only users of water resources but are also partially engaged in their management. This community is made up of organizations representing stakeholder groups and

---

government regulation and privatization can also play important role in dealing with collective action problems (e.g., Ostrom, 2007).

government agencies that have different preferences and responsibilities regarding the use and distribution of the resources. In regional SESs the emergence of self-organization may differ in scope and scale. It can be restricted to a specific stakeholder group, be location-specific (e.g., management of a tributary) or issue specific (e.g., clearing of alien vegetation). Some forms of self-organization are more permanent (e.g., a water distribution system shared among members of an IB) whereas others may dissolve after the management goal has been achieved (e.g., an alien species clearing activity). Self-organization remains a critical feature of robust governance arrangements in regional SESs because it allows groups of actors to come together and respond promptly to emerging problems and changes. However, in comparison to local SESs, the changes and tasks in regional SES require different types of actors to come together and self-organize (related to the case study: different parts of the Berg management network). This means organizations must have the capacities and linkages that allow them to organize.

The literature on the commons has highlighted several motivating factors that can trigger self-organization. Among them are the level of dependency on the resource, a specific crisis situation, and the protection of existing property rights (Seixas and Davy, 2007; Varughese and Ostrom, 2001). With regard to the management of SESs, this presupposes that a common understanding of the condition of the SES exist (Varughese and Ostrom, 2001) that leads to joint problem definition and goal setting (Pretty, 2003). Hence, access to legitimate information about the state of the resource is vital for motivating self-organization (Varughese and Ostrom, 2001). Ostrom and Ahn (2003:10) emphasize that for local stakeholders to establish effective collective action processes, they need "sufficient local autonomy to invest in the social and physical capital involved in building systems and monitoring performance". Following Basurto (2013) and Ostrom (2000), autonomy is understood here as the right and ability of the resource user to develop their own institutions (e.g., determine access and user rules) without external authorities challenging them. Given the presence of multi-level linkages in regional SESs, the actions and decisions by higher level authorities will often directly affect the incentives for individuals or groups to engage in the design and maintenance of institutions for self-governance (Basurto, 2013; Ostrom, 1990).

The sections above suggest that various interacting factors can facilitate or obstruct collective action and self-organization. Many of these factors are context specific and tend to increase with the size of the "community" or SES. Elinor Ostrom (1990, 2000, 2005) has powerfully demonstrated that, regardless if one refers to self-organization at the local level or to collective action in larger, more complex regional SES, societal cooperation is based on three key building blocks: communicative processes, reciprocity, and trust. Based on her extensive empirical work, Ostrom has developed a set of design principles that help to explain under what conditions trust and reciprocity can be built and

maintained for societal cooperation in form of sustained collective action. Findings from empirical studies across the world suggest that robust governance arrangements are those that incorporate a large number of these design principles (Anderies et al., 2007). In relation to governance, robustness is defined in this study as the capacity to maintain specific performance objectives even when faced with changes or shocks (van Laerhoven and Ostrom 2007; Hutjens et al., 2009; Mumby et al., 2014). Performance objectives relevant to this study would be the maintenance of key water management functions, the efficient response to water management challenges and the equitable and accountable distribution of cost and benefits. The design principles are introduced in the subsequent sections below. They guide the empirical investigation into the collective action initiatives presented in Chapter 6.

3.2.2. Ostrom's eight design principles for guiding the assessment of collective action

Ostrom understands the design principles as elements or conditions that help to account for successful, long-term collective action (i.e. the compliance to the rules which safeguard the sustainability of the resource (Ostrom, 1990). "The design principles work to enhance participants' shared understanding of the structure of the resource and its users and of the benefits and costs involved in following a set of agreed upon rules" (Basurto and Ostrom, 2009:52). In doing so, they help groups of actors to sustain and build cooperation over a long period of time (Ostrom, 2009a;) and to establish robust, yet adaptive, governance arrangements. Wilson et al. (2013: 22) go so far as to state "that the principles have a wider range of application than CPR groups and are relevant to nearly any situation where people must cooperate and coordinate to achieve shared goals. Table 3.3 lists the eight design principles that are important conditions for trust and reciprocity. They also serve in this thesis as indicators for robust governance i.e. governance arrangements that can sustain key management functions and address management challenges in light of socio-economic and ecological changes.

Table 3-3: The eight design principles- conditions for trust and reciprocity
(adapted from Ostrom, 1990: 90; Cox et al., 2010)[61]

Principle 1: Well-defined boundaries:
a. **Group boundaries**: it is important to identify who has a right to use the resource(s) and who should pay for the cost of maintaining these resources. Ostrom (2005:261) writes that "this principle enables participants to know who is in and who is out of a defined set of relationships and thus with whom to cooperate." The principle, furthermore, helps to clarify mutual responsibilities and benefits. In the context of this thesis, group boundary determination relates to identifying who the relevant users and managers in the Berg catchment are. Who is benefiting to what extent from the resources and who pays for what cost. b. **Resource boundaries**: the boundaries of the resource system should be clear to all involved. Clarifying and agreeing on the resources boundaries allows the separation of the system from the larger bio-physical environment (Cox et al., 2010) and specifies which components are part of the system. Understanding and agreeing on the group and resource boundaries is important for assessing positive and negative externalities. Ostrom (2009a) points out that boundaries must be defined by the users themselves. Given the complexity of regional SESs these boundaries will most likely be negotiated and overlapping. In the context of this thesis it implies that it is important for those involved in the management of the Berg catchment agree and are aware of the boundaries of the system as well as of all other organizations involved in the management activities.
Principle 2: Congruence between appropriation and provision rules and local conditions
a. **Cost** must be perceived as at least **equal to benefits**: rules for distribution of costs must match rules for distribution of benefit (Ostrom, 2009a) Principle 2a refers to the fairness of cost-benefit distribution in the system. That is, rules that allocate the benefits should be proportional to the inputs of the actors. If it is made clear how inputs to the collective action (or for maintaining the SES) relate to the benefits actors gain from the SES, then the willingness of the participants to contribute to collective action is enhanced (Ostrom, 2005). b. The **rules must match environmental conditions**. For example, how much water to abstract

[61] Principle 2a and 2b are used in this thesis in the same manner as used in Ostrom (1990). In contrast Cox et al. (2010) used the reversed ordering.

in which locations and in which season.

Principle 3: Collective-choice arrangements

Actors involved in the collective action must be able to participate in the design, enactment and modification of the rules that are supposed to govern their behavior. This enhances the likelihood that rules match local and social conditions (e.g., principle 2a) and that they are perceived as fair. This in turn enhances rule compliance. Ostrom (1990) states that if actors are not involved in modifying these rules over time, the information about the benefits and costs as perceived by different actors is not fully taken into account in the efforts to adapt to new conditions. As a consequence, actors may begin to perceive the costs of their inputs as being higher than their benefits. They therefore will start no longer complying with the rules.

Principle 4: Monitoring

a. **Monitoring of environmental condition:**
   Informs about changes in the SES, effectiveness of management practices as well as creates a better understanding of the SES

b. **Monitoring of the human environment interaction**: includes user and management practices

Monitoring appears to be one of the most critical principles because not only does it inform about the behavior of others and level of rule compliance but also what the effects of the governance arrangements have on the resource system. In order for monitoring to become a rule compliance mechanism, it is important that the monitoring activities are viewed by all as credible. That is, monitoring must take place systematically and regularly and the monitors must be accountable to those participating in the collective action.

Principle 5: Graduated sanctions

Like monitoring, graduated sanctioning is an important mechanism for rule compliance. Graduated sanctions help to maintain community cohesion. This mechanism signals that wrong doing is noticed by others and not tolerated. But it also provides room for redressing errors and for establishing reasons behind the rule violation.

Principle 6: Conflict-resolution mechanisms

Easily accessible and low cost conflict resolution mechanisms are necessary for assisting with rule interpretation as well as negotiating trade-offs or conflicts of interests that may arise.

Principle 7: Minimum recognition of rights

The rights of local stakeholders/managers to devise their own rules needs to be granted by higher level authorities. This provides the necessary autonomy for self-organization while at the