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

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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.

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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.

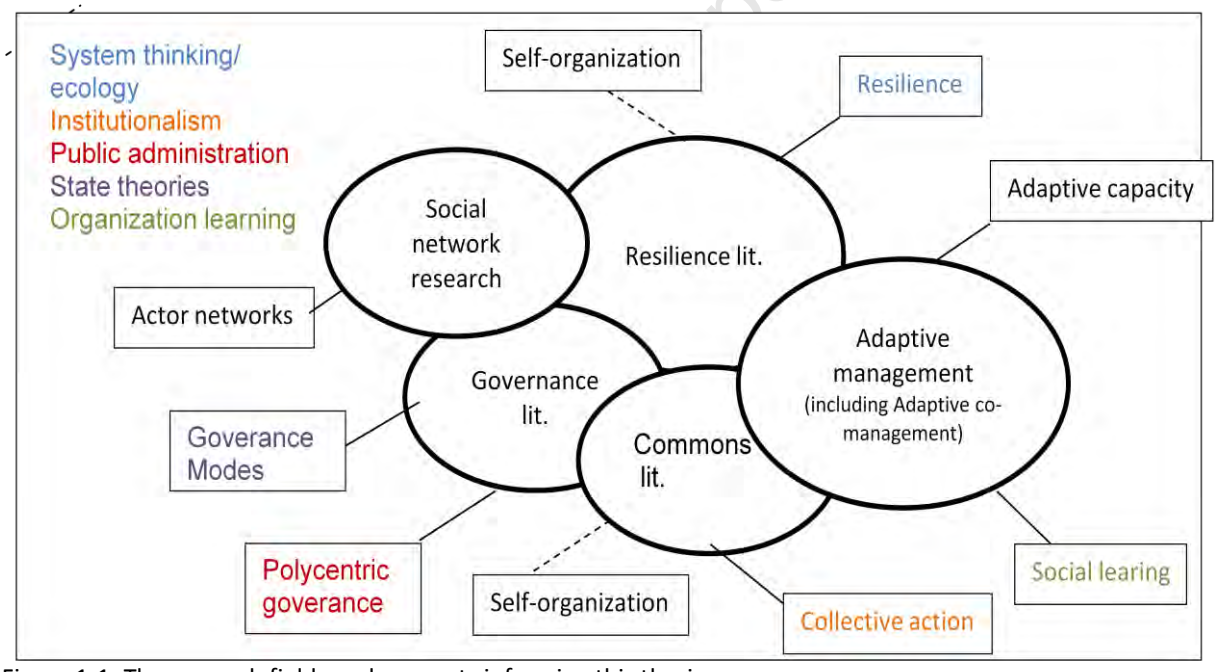

Figure 1-1: The research fields and concepts informing this thesis

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).

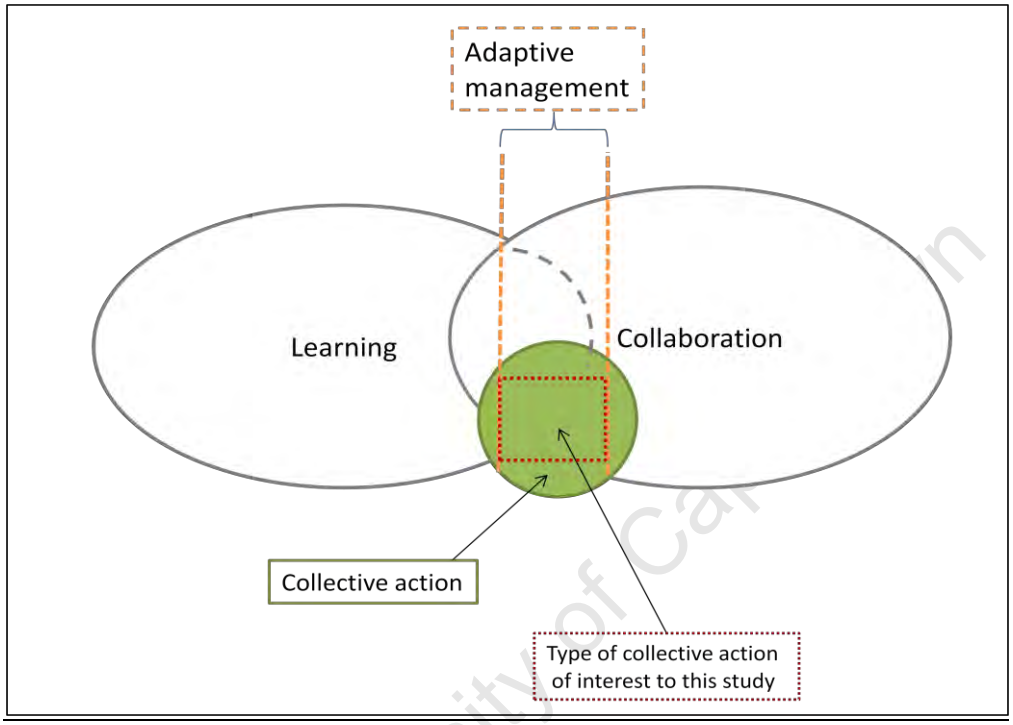

Figure 2-1: Specifying the relationship among collaboration, collective action and AM

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).

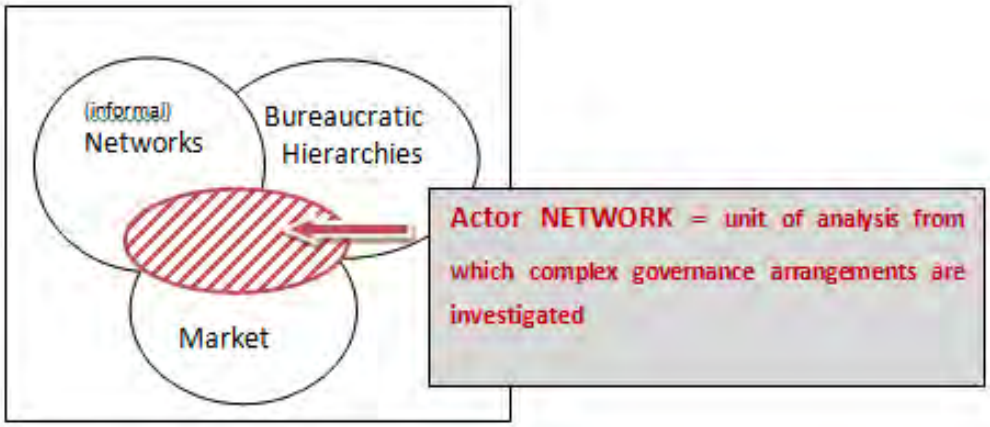

Figure 2-2: Illustration of how networks are conceptualized in this study

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

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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.

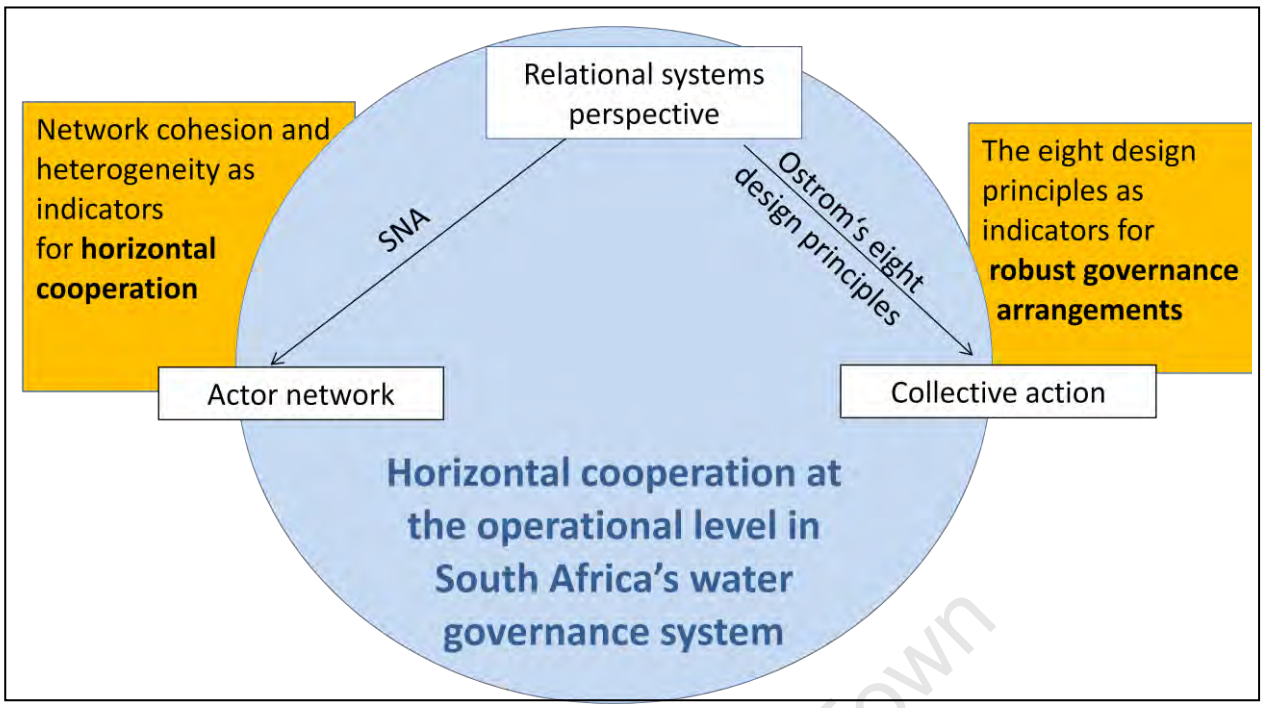

Figure 3-1: The proposed analytical framework for assessing horizontal cooperation

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.

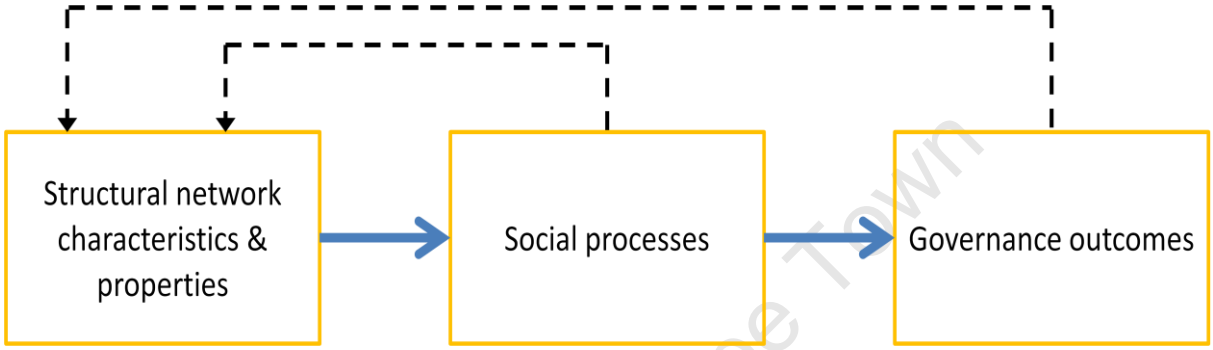

Figure 3-2:The influence of network structure on social processes that determine governance outcomes. Arrows indicate the direction of influence.

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).

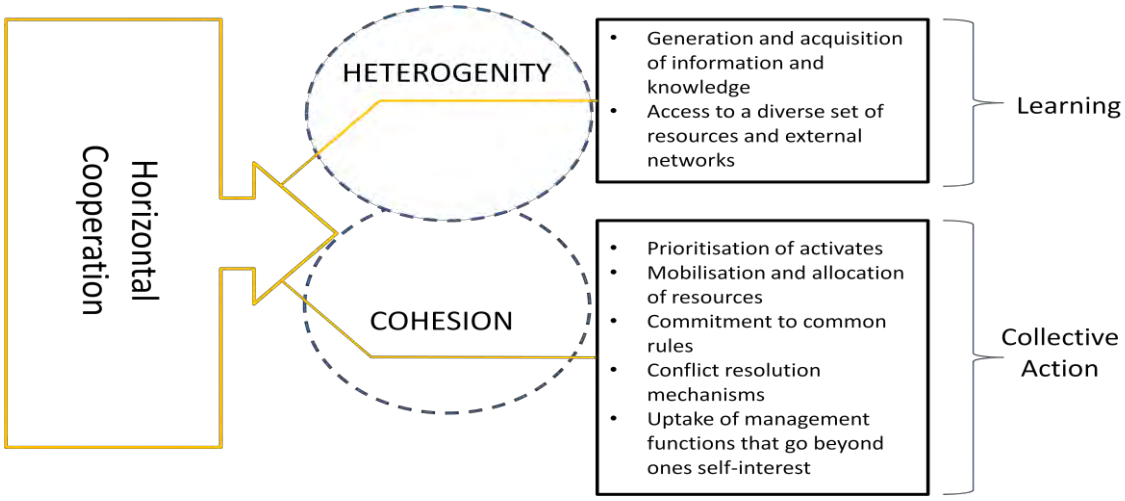

Figure 3-3: Heterogeneity and cohesion as important indicators of horizontal cooperation influencing learning and collective action

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.

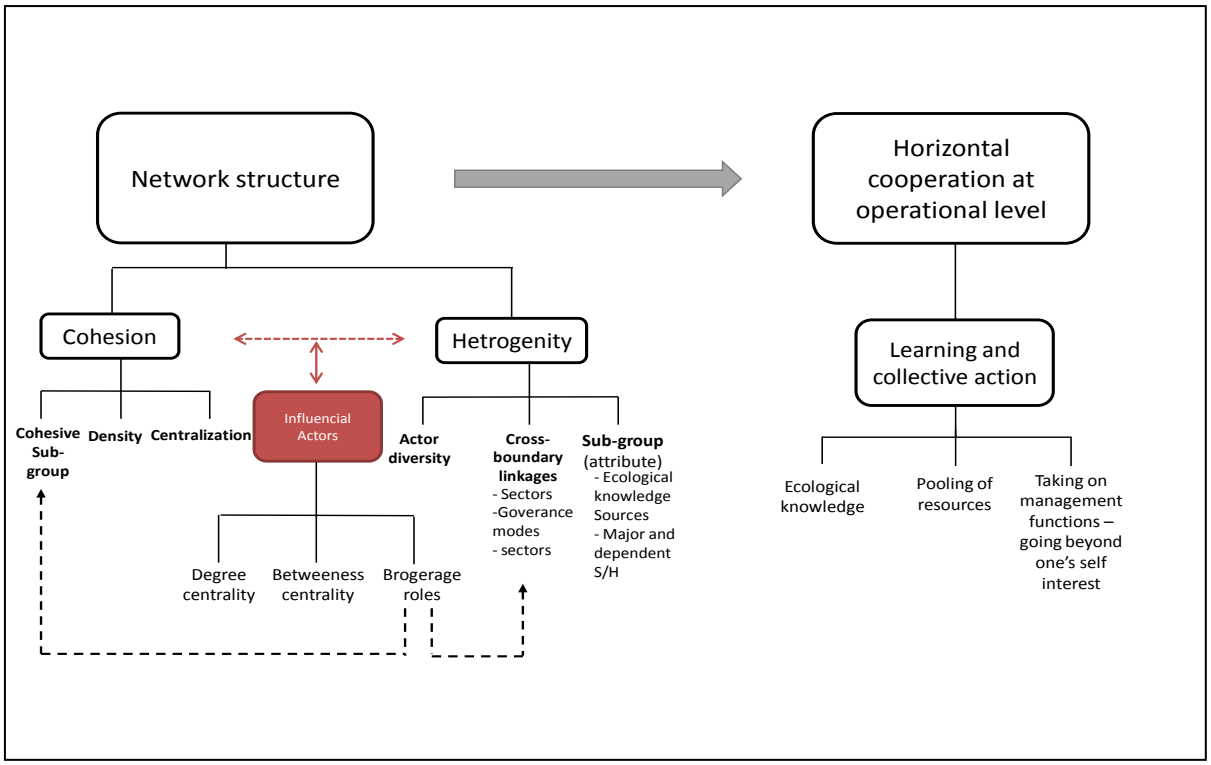

Figure 3-4: Overview of the social network measures used for analyzing cohesion and heterogeneity.

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.

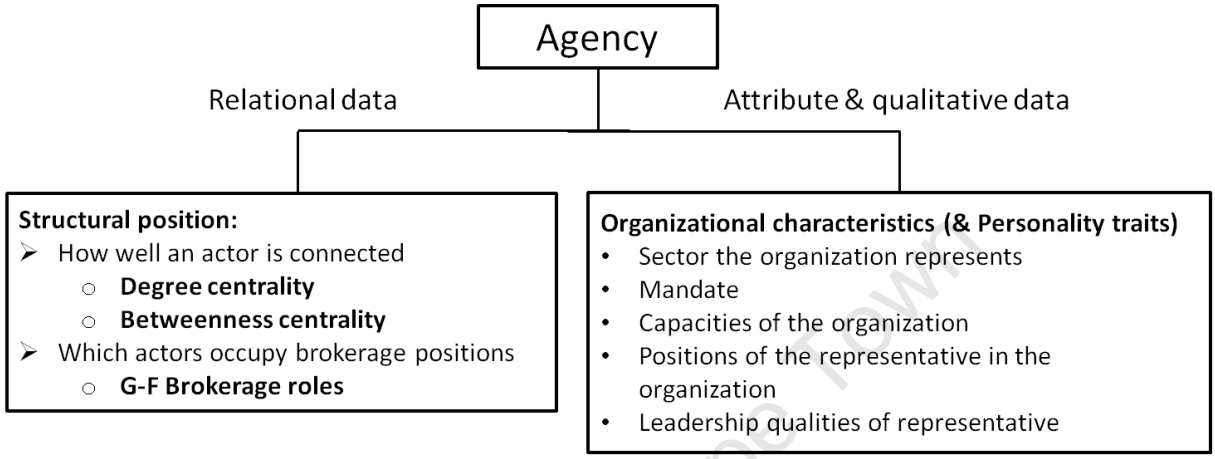

Figure 3-5: Depiction of Agency: structural position and organizational/ personality traits.

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.

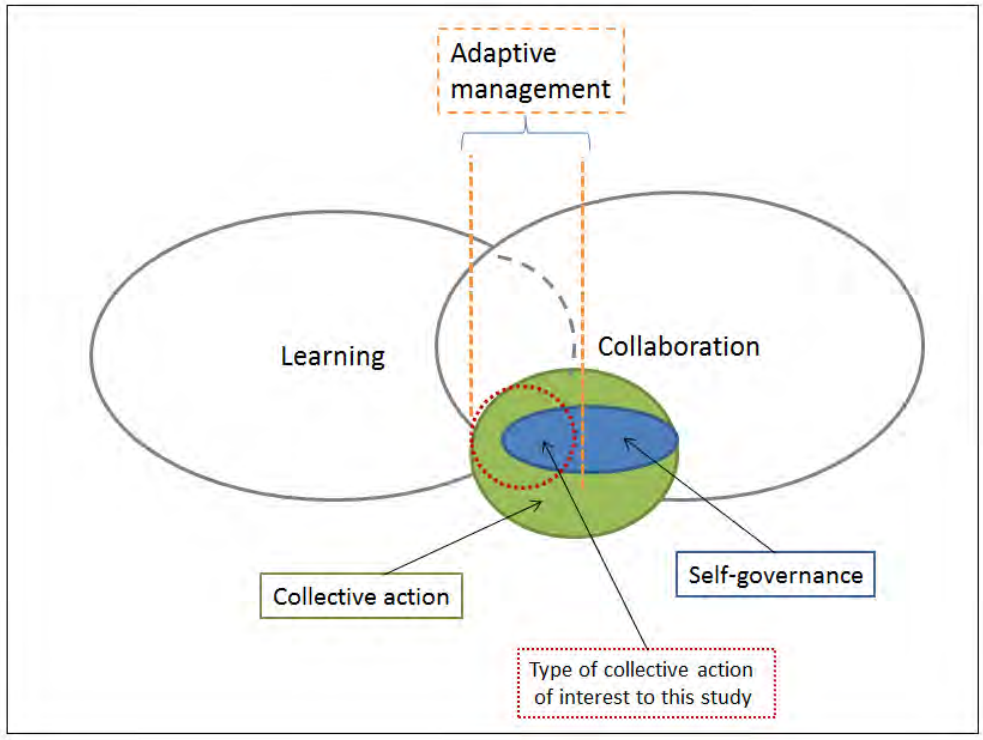

Figure 3-6: Specifying the relationship between collaboration, collective action and self-governance

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

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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

same time increasing the likelihood of receiving higher level support and legitimacy for self-organized arrangements.

Principle 8: Nested enterprises

The organization of governance activities (e.g., monitoring, conflict resolution and other management activities) in multiple layers of nested enterprises is particular relevant for complex and larger SESs. Nesting allows for the necessary cross-boundary cooperation in larger SESs. Since smaller units are maintained, it is easier to develop the trust and reciprocity necessary for initiating and maintaining cooperation within the units (Ostrom, 2010). By nesting each level of organization in a larger level, externalities between groups can be addressed in larger organizational settings that have a legitimate role to play in relation to the smaller entities" (Ostrom,2000:8).

Cox et al. (2010) state that nesting may occur between user groups and larger government jurisdictions or between user groups themselves. It is important that the smaller units partially keep their autonomy and are not fully absorbed into larger units (Marshall, 2008). Marshall (2008) further points out that nesting allows for effectively dealing with vertical assurance problem (maintaining a certain degree of autonomy and collective choice rules) and horizontal assurance problem (higher level assists, e.g., rule enforcement, sanctioning, monitoring)

Some authors have cautioned that findings from studies of small-scale SESs (i.e. local commons) may not easily apply to collective action in regional and global SESs (e.g., Young, 2002; Cox et al., 2010; Stern, 2011; Brondizio et al., 2009; Hutjens et al 2009). In contrast to small-scale SESs (which are often governed by one or two identifiable spatial communities) larger systems are characterized by a greater complexity in terms of actors, relations among them as well as ecological sub-systems (Lebel et al., 2006). Any kind of self-organization, for example, will often need to take place in heavily regulated policy fields. Hence, governmental authority and market structures are involved too. Furthermore, in regional SESs, collective action may not necessary originate from the self-organizing efforts. As previously mentioned, large numbers of actors with multiple interests and perspectives make it challenging to arrive at a shared understanding of the issues especially when resources for collaboration and collective learning are limited. External actors can play a key role in initiating collective action especially among groups of actors that either differ substantially in their respective interests or among groups that may not have the necessary means to establish the required deliberation and collective learning processes. However, if collective action is externally initiated, there is the danger that it may not be sustainable or perhaps even reduce existing social capital

(Vollan, 2012). External interventions can, for example, change underlying incentive structures to cooperate and thus crowd out the basic motivation to cooperate (Bowles, 2008 in Vollan, 2012).[62]

It is argued in this thesis that Ostrom's design principles remain of great value to the study of regional SESs because trust and reciprocity continue to be the foundation for collaborative relations in such systems. That is, while regional SESs are often part of highly state-regulated and market-driven policy fields, it is through interpersonal relations that the arrangements which govern these systems are being negotiated and structured.

Other studies have already used the design principles in rather complex institutional settings (e.g., Termeer et al., 2013). Cox et al. (2010:13), who conducted a thorough review of 91 case studies to evaluate the validity of the design principles, state that several of these principles may be relevant for the management of larger resource systems: "the proportionality of costs and benefits, conflict-resolution mechanisms, nested institutional arrangements, and effective and participatory collective-choice arrangements seem particularly relevant". Similarly, Stern (2011:229), after a comparison between local and global CPR, concludes that "Ostrom's pioneering work has considerable relevance for commons that are quite different from those she studied. Ostrom's institutional analysis approach and its focus on self-governance institutions seems to have useful lessons to teach to those involved in governing larger commons, who often pay insufficient attention to the potential of such institutions."

Finally, it needs to be noted that while this thesis is interested in the possibility and feasibility of catchment-wide collective action, the assumption is that an important part of collective action in the catchment is comprised of smaller overlapping collective action initiatives (which are either issue or location specific). These initiatives may to a certain extent be subject to the similar dynamics that determine self-governance and collective action in the SESs studied by Ostrom and her colleagues. The argument put forward in this chapter is therefore, that lessons from successful CPR governance, articulated through Ostrom's eight design principles, are a good starting point for understanding collective action and horizontal cooperation in complex regional SESs.

[62]Vollan (2012) argues that communities often lack resources for sustaining collective action that is initiated from the outside as issues of coordination, transparency and leadership may arise. His findings suggests that measures taken by external actors (in his case the South African government) to stimulate collective action within communities (e.g., via the establishment of single purpose committees) can lead to a decline of social capital (i.e. a negative effect on trust and reciprocity) within the communities. This shows that it is not easy to build social capital via external structures.

3.2.3. Relating the design principles to features of AM and polycentric governance

Looking at the functioning of the principles from a broader perspective (see Figure 3-7), Anderies et al. (2004) have pointed out that Principles 1, 2 and 3 create the conditions that reduce the problem of free-riding and assist in negotiate the problem of subtractability (here broadly understood as negotiating acceptable trade-offs so that most needs can be met). Principles 4, 5 and 6, on the other hand, provide important feedback controls on the actions of others and on the SES. Finally, Principles 7 and 8 are of importance for creating the necessary linkages within larger more complex SESs while at the same time allowing for space for self-governance in smaller sub-units. Principles 7 and 8 are furthermore vital for enhancing the functioning of the other six principles.

Relating the design principles (listed in Table 3-3) now to the key features of AM (introduced in Chapter 2), it becomes evident that Principles 1, 2 and 3 are critical for establishing important conditions for collaboration. Principles 4, 5, and 6, on the other hand, provide opportunities for learning and knowledge generation about the SES. Finally, Principles 7 and 8 facilitate cross-boundary linkages which allow the development of effective multi-level governance arrangement. Hence, conceptually the design principles create a critical linkage between AM and polycentric governance. From an analytical point of view the design principles allow the assessment of the extent of AM and of polycentric governance in the governance arrangements through which the Berg catchment is managed, which in turn allows the drawing of conclusions about the robustness of the existing governance arrangements. In other words, it is assumed in this study that governance arrangements that contain features of AM and polycentric governance are robust.

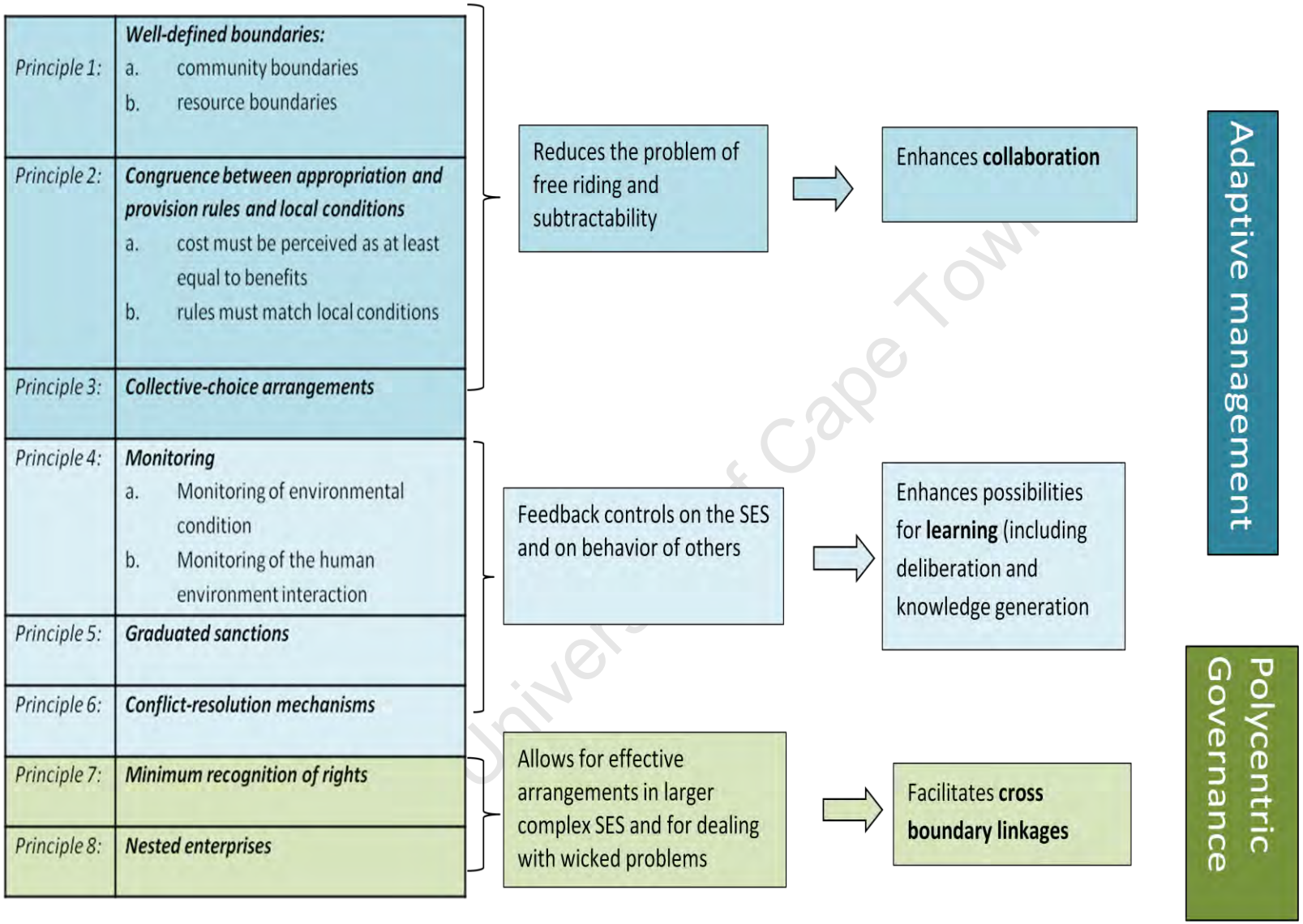

Figure 3-7: The design principles linking and reinforcing AM and polycentric governance (adapted from Ostrom, 1990; Cox et al 2010; Anderies et al., 2004)

3.2.4. Accounting for additional factors fostering collective action in regional SESs

Ostrom's eight design principles are not treated in this thesis as a 'tick list' to show whether or not a collective action initiative is successful. Rather, they serve as a point of reference for evaluating if these collaborative efforts have the capacity to become robust and adaptive governance arrangements. To be able to compare the collective action initiatives that were identified with the help of the formal SNA and to allow for a systematic investigation of their individual and joint contributions to AM, the selected initiatives are organized according to specific themes. They cover the motivation for, internal dynamics within, larger context, and potential contributions to management functions for each initiative (see Table 3-4). The themes were developed with the intent of detecting additional factors that may shape collective action in regional SESs. While most of Ostrom's work has focused on institutional analysis, the proposed themes provide the space to explore the influence of agency (leadership, champions, bridging organizations) and emerging processes resultant of the interactions.

Table 3-4: Organizing themes for comparing and assessing collective action

Motivation:
• internally initiated (self–organized) or externally initiated incentive structures
• type of incentive structures
• level of crisis perception
Internal dynamics:
• Shared problem definition among participants
• Existence of learning processes: frequency of meetings and level of participation
• Integration of ecological knowledge
• Prioritization of activities: e.g. joint management plan
• Pooling of resources
Uptake of key management functions: going beyond one's self interest (internal)
• Leadership type: top down or emerging
• Champions: actors that try to find innovative ways to advance the new ideas or approaches in order to transform or change a situation or their organization
• Level of cooperation with other collective action initiative
• Bridging actors (to other initiatives) or processes
Larger context:
• Support structures: access to financial resources and skills
• Access to scientific information
• Integration into the larger catchment management processes
Outcome:
• Uptake of key management functions: going beyond the interest of the specific initiative (catchment wide)
• Strengthening of cross-boundary relation: internal: among participants, external: within the larger catchment

To summarize the intended approach: Ostrom's eight design principles are utilized as the primary tool for identifying constraints affecting collective action and the capacity to self-organize in the Berg catchment. The organizing themes, on the other hand, provide the space to explore factors other than the design principles that may be critical for collective action in regional SES.

3.3. Summarizing the proposed analytical framework: actor networks and collective action

In this chapter, the two concepts of actor network and collective action have been operationalized in ways that allow the description and assessment of horizontal cooperation in complex governance arrangements that govern regional SESs. Section 3.1 demonstrated the utility of analyzing actor

networks through a formal SNA helps to tease apart how social structures created by patterns of relations enhance or hinder AM of SES. Furthermore, a strong case has been made why network cohesion and network heterogeneity are valuable indicators for assessing horizontal cooperation in the context of learning and collaboration. It was further shown how those two network characteristics can be quantitatively assessed through a variety of complementary network measures.

Section 3.2, on the other hand, convincingly argued that Ostrom's eight design principles provide a valuable point of reference for identifying constraints to collective action and for evaluating the robustness of the governance arrangements that have evolved from the existing horizontal cooperation. Perhaps the most exciting and valuable contribution that section 3.2 makes is that it clearly was able to demonstrate how the design principles bring to the fore key features that characterize AM and polycentric governance In doing so the principles create, by implication, a linkage between the two concepts.

4. Chapter: Methodological considerations and introduction to the research site

Chapter 3 provided a rationale for combining a SNA with a detailed investigation of collective action for the evaluation of horizontal cooperation. Furthermore, an argument was made for the suitability of the concept of actor network and of Ostrom's design principles for examining the governance of regional SESs. This chapter provides a detailed introduction to the Berg catchment as the research site. Furthermore, the chapter elaborates on the design, content and execution of the SNA and describes the methodological steps taken for the qualitative analyses of the collective action initiatives. Apart from familiarizing the reader with the Berg catchment, it will enable her to grasp the qualitative and quantitative analyses in the preceding chapters. Before addressing the chapter's aim, the benefits of choosing a single case study in combination with a mixed method approach for addressing the overarching research question are discussed. The subsequent sections describe how the relational data for the SNA was generated and analyzed. Besides defining the network boundaries, the reader is also informed about the researcher arrived at the final actor set and the collaborative network (the multiplex network N). Following an overview of the various qualitative research method techniques, the chapter concludes with a reflection on the limitations of this research and ethical considerations.

4.1. Single case study approach

The previous chapters have already indicated that conceptually and methodologically it is not a straightforward endeavor to examine horizontal cooperation in regional SESs characterized by complex governance arrangements. It is therefore appropriate to focus on a single in-depth case study to examine how actor relations enhance or hinder learning and collective action. The advantage of using a single case study is that it allows for a thorough and detailed inquiry into the observed phenomenon (Yin, 2003). As the study is interested in the relational factors that shape AM, a rich and in-depth inquiry allows the development a holistic account of patterns of interactions among the identified actor network, as well as how those relational factors and specific social processes shape each other. Although case study knowledge may not always be generalizable, it produces important context specific knowledge which helps to improve the understanding of complex phenomena and to test existing scientific explanations of those phenomena (Eisenhardt, 1998; Flyvbjerg, 2006). Its strength derives from its consideration of the background, development, current conditions, and interactions of the research subject(s) (Yin, 2003). Adopting such an approach for this study meant that the actor network could be examined in its wider context rather than in isolation and that the interplay of key processes and drivers could be examined.

Furthermore, an in depth case study can tell us how various quantitative analyses from the SNA might be complemented with qualitative methods in order to situate actor relations and social processes within the broader context that provided the conditions for their emergence. This in turn may lead to a systematic methodological framework that can be employed in other case study research.

Yin (2003) points out that one of the greatest challenges is to select a representative case study which can either communicate or challenge existing theories and which allows for the generalization to other case studies. Although some might question the representativeness of the chosen catchment, the characteristics of the actor network, and the context in which it is embedded, are not unique but represent a situation that can be detected in other regional SESs catchment areas in South Africa and across the world. Following Yin's (2003:97-105) suggestion, the study combined multiple sources of evidence, such as focus groups, semi-structured interviews, participant observations, document analysis and a comprehensive quantitative analysis of the actor relations to be able to describe and analyze horizontal cooperation in regional SESs.

Case study research requires from the researcher an intensive engagement with the case. This can lead to two types of challenges. Firstly, the researcher may lose her or his objectivity. Secondly, the researcher may start feeling overwhelmed by the large amount of data and information that are obtained from the various techniques used in the case study. Regarding the first challenge, it needs to be noted that scientific inquiry is never completely neutral. Hence, a certain degree of subjectivity and arbitrariness is bound to remain. Therefore, it is of paramount importance to be transparent in the different research steps and to remain impartial towards the actors participating in the research. With respect to the second challenge, to avoid losing sight of the research objectives when dealing with the substantial amount of data derived from the various techniques, all quantitative and qualitative data was systematically organized from the beginning. How this was achieved is described in later sections of this chapter.

4.2. Mixed method approach

According to Johnson et al. (2007:113) mixed method research is an "approach to knowledge (theory and practice) that attempts to consider multiple viewpoints, perspectives, positions, and standpoints (always including the standpoints of qualitative and quantitative research)". In this study the main reason for using a mixed method approach was to lead to thicker and richer data on horizontal cooperation and to allow for the synthesis of the different concepts introduced in Chapters 2 and 3.Furthermore, mixed methods strengthens triangulation, i.e. the same phenomenon (e.g. learning) can be investigated through different methods (see Johnson et al.,2007).

Figure 4-1 shows the sequential approach used; where first the qualitative pre-study informed the design of the quantitative research instrument (SNA survey) and the findings from the SNA provided the basis for the qualitative interpretation and analysis in Chapter 6. Empirical data that was acquired through the research process, via the various qualitative research techniques, helped in the interpretation of some of the quantitative findings.

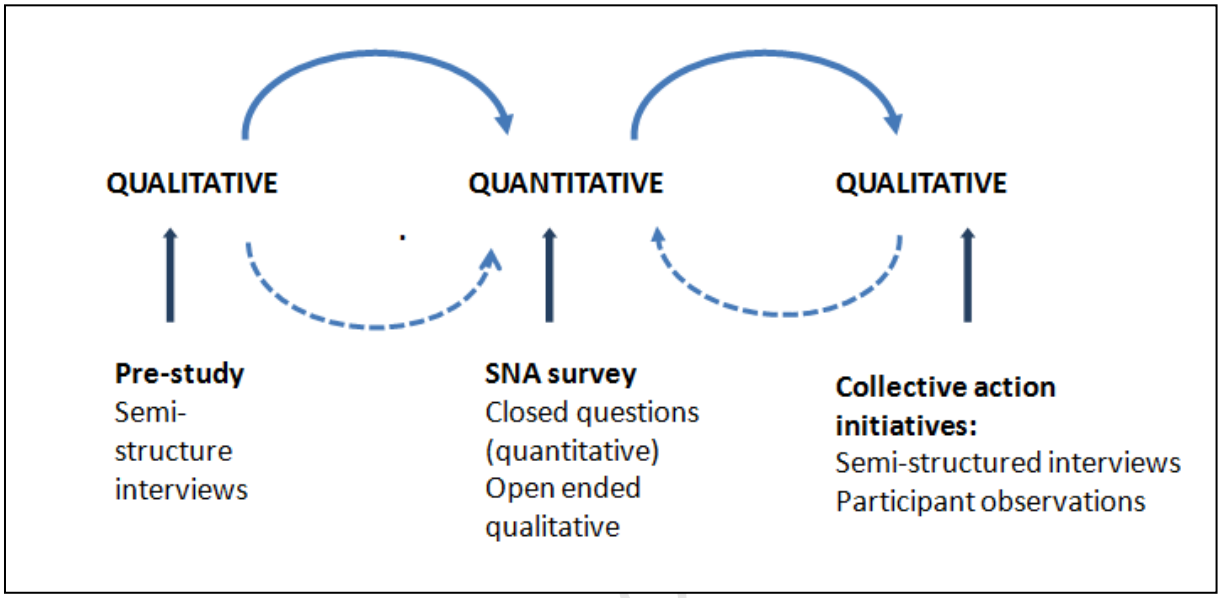

Figure 0-1: Sequence of the mixed method approach

The main argument against using mixed methods stems from the view that the paradigms upon which qualitative and quantitative methods are based have different views of reality and therefore, a different view of the phenomenon under study (Sale et al., 2002). However, it is exactly this point which the researcher considers the strength of the approach. The complementary application of qualitative and quantitative research methods in this study allow the researcher to establish a more holistic and complete account of horizontal cooperation as the factors and processes that that influence and are influenced by horizontal cooperation can be explored from different angles. As Eisenhardt (1989: 538) writes "[q]ualitative data are useful for understanding the rationale, or theory underlying relationships revealed in the quantitative data" whereas quantitative data may "indicate relationships which may not be salient to the researcher". In this sense the qualitative data can almost be seen as the required bridge between the relational data derived from the quantitative network measures and the responses to degrading water quality.

4.2.1. Unit of analysis

The unit of analysis is the operational level of South Africa's water governance system. This level is exemplified in this thesis through the actor network with the ultimate responsibility for the management of the Berg catchment. Actors are organizations rather than individuals, as explained in the section below.

In this study, actors are defined as organizations involved in the management of the Berg River and its larger tributaries. The focus on organizations rather than individuals is a reasonable choice, as the river is primarily managed by organizations rather than individuals. [63] Even private land owners are part of larger organizations or associations that represent their interests in the management of water resources. Furthermore, organizations tend to provide more stable 'nodes' (in network terms) in comparison to individuals. Although their formation takes time, the institutionalization process that characterizes most organizations makes them more durable structures (Ernstson, 2008). Hence, many organizations will outlive specific individuals. Finally, organizations as a whole also tend to have access to a wider pool of resources, whereas individual members of the organization may have limited access to those collective resources (Ernstson, 2008).

The overarching criterion for organizations to be included in this study was that they actively participated in the management of the Berg River. This could either be directly through the physical observation and modification of the river system including adjacent land (e.g., monitoring, management of abstraction and discharge etc.) or indirectly through activities such as the generation and provision of ecological knowledge or the provision of incentive structures (e.g., financial or technical support, directives) that enhance the willingness of organizations to contribute to water management. Potentially relevant organizations were elicited through key expert interviews (pre-study), document analysis (e.g. the register of the CMA Reference group), participant observation (e.g. public water management meetings) and the survey respondents (adding names to the recall list).

4.3. Research Site: The Berg River catchment

Before describing the Berg catchment a brief explanation is provided for its usefulness as a research site for investigating South Africa's water governance system at the operational level:

i. The Berg catchment is a complex SES with many different users that have competing demands and interests on water resources from the Berg River system. Establishing a sustainable and effective water management system that is capable of dealing with emerging challenges is therefore vital for the region's water security.

ii. Water management in the Berg catchment has to be carried out without a functioning CMA[64] in place and without the guidance of a Catchment Management Strategy. This is a situation that can be observed in many of South Africa's catchment areas.

[63] A similar approach was used by Ernstson et al. (2008) and Stein et al (2011).

[64] The lack of an existing CMA is especially useful due to fact that this study is concerned with revealing regular patterns of interactions among organizations involved in water management at catchment level. In the initial

iii. The Berg catchment is a well-resourced catchment in terms of expertise and financial possibilities. It seems therefore reasonable to think that actors, despite all the existing constrains related to the slow implementation of the reform process in the water sector, have the necessary capacities to self-organize themselves in ways that enable them to manage the catchment effectively.

The Berg catchment is located in the Western Cape north of Cape Town and spans an area of 7,715 Km². The Berg River, which has a length of 285km, rises in the Franschhoek and Drakenstein Mountains and discharges into St. Helena Bay on the West coast. It has nine major and six minor tributaries. The Berg River is a major source of the region's water security. It serves a population of 650,229 in the Cape Winelands region and 320,929 in the West Coast, of which 79% live in urban areas and 21% in rural areas (Berg River Task Team Report, 2009). It is part of a very complex water supply scheme that connects the catchment to the neighboring Breede catchment and to the City of Cape Town which receives a large part of its drinking water from the Berg through the scheme.

Land use within the catchment consists of mainly dryland wheat farming, irrigated agriculture, livestock farming, natural conservation, and urban areas ((status quo report Western Cape). These uses along with a steady population growth[65] caused by in-migration to the metropolitan area of Cape Town and its surrounding municipalities, due to the region's robust economic growth rate, have placed considerable pressure on regional water resources.

phase of this study the two existing CMAs (Breede CMA and Inkomati CMA) were just in the process of being established. Hence these organizations still needed to create their organizational capacities (e.g. employment of staff) and had not established regular patterns of interactions to other stakeholders in the respective catchment.

[65] Population growth rate for the Cape Winelands region and for the West Coast is 0.4% and 2% respectively (Berg River Task Team Report, 2009).

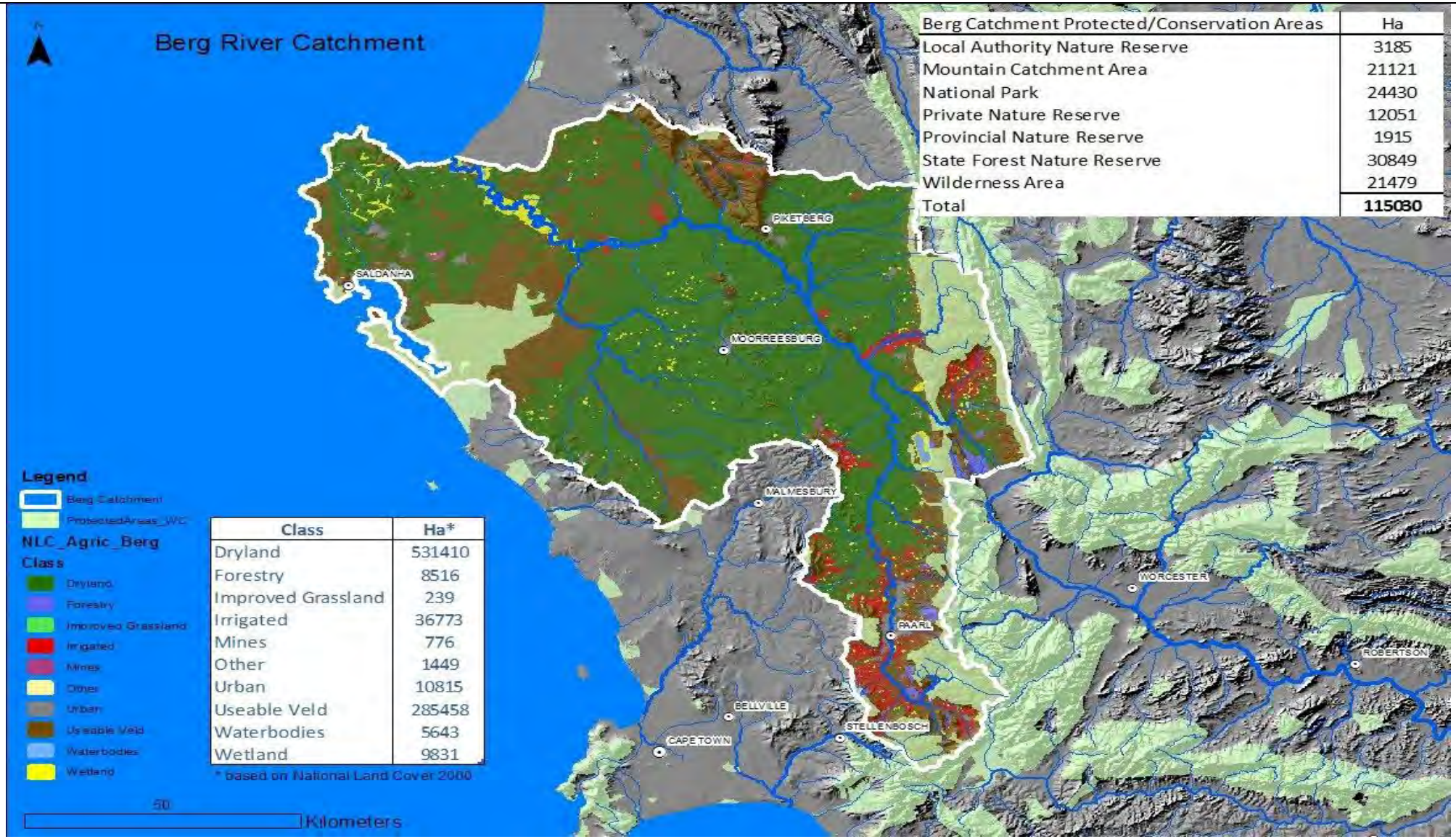

Figure 0-2: Land use in the Berg catchment (source: Department of Agriculture Western Cape, GIS Department, Courtesy of Mike Wallace)

One of the major stressors in the catchment is the poor and degrading water quality in the river, which is primarily a result of pollution (DWA, 2004b). According to the Berg River Quality Task Team Report 2009 (2009: 6-7) among the major causes for water pollution are:

- Spillages from 'non'- functional or inadequate sewage plants and pump stations;
- Spillages due to heavy rains when storm water is diverted to Waste Water Treatment Works;
- Raw sewage and household waste dumped into storm water drainage channels;
- Grey or black water being drained into legal and illegal storm water channels;
- Illegal discharges from industry and agricultural practices;
- Salination of rivers and dams through run over geology and fertilizers.

Of great concern is the pollution caused by untreated or poorly treated sewage. "This pollution emanates from two types of sources - informal housing areas without proper sanitation services and systemic failures of the wastewater treatment works and sewage systems of towns in the area" (Berg River Quality Task Team Report, 2009). The local municipalities, especially from the upper catchment area, have had significant impact on the river in terms of discharge and related pollution problems.

Climatic stresses[66] are likely to exacerbate the problem of degrading water quality as the projected hotter temperatures and shorter rainfall periods, for example, will lead to a greater water evaporation rate, reduced water quantity and higher concentration of nutrients in the rivers. (pers. comm. Barnes, 2009). More intense rainfall events over shorter periods of time, on the other hand, will exacerbate the problem of flooding "of storm water channels and the 'popping' open of drainage systems causing raw and untreated effluent to spill onto the surface which eventually flows back to the river" (Berg River Quality Task Team Report, 2009). Enhanced climate variability and future climate change therefore are a significant threat to the region's water resources; socio-economic activities[67]; and livelihoods (productive livelihoods and health)[68] that are dependent on adequate water quality.

[66] The region in which the catchment is located has been identified as a 'climate hotspot` – being very vulnerable to enhanced climate variability and future climate change (Midgley et al., 2005). Climate change projections for the Western Cape indicate "a weakening of winter rainfall…, a shift to more irregular rainfall of possible greater intensity, and rising mean, minimum and maximum temperatures" (Midgley et al., 2005: i). The drier and warmer climate will have serious implications for water resources in the Western Cape in terms of water supply and quality.

[67] One of the sectors highly dependent on good water quality is the fruit export sector. During the 2004/5 season the sector was in danger as retailers from the EU threatened to cancel fruit imports from the region due to the contamination of the Berg River (pers. comm. Jannie Kirsten, 2009,). A study on the impact on the

Given the significance of the problem, degrading water quality and related issues present a fitting context for investigating how the Berg management network jointly deals with problems and changes in the catchment area. Furthermore, the specific focus helped to specify the boundaries, actors, activities and relations that are the focus of this study.

To be able to put the processes that are taking place in the Berg catchment in a historic context and to familiarize oneself with important water management organization from the South African water governance system the reader is referred to Appendix 4.5 and 4.4 respectively.

4.4. Social Network Analysis

4.4.1. Data Generation

4.4.1.1. Network boundary:

One of the major tasks when studying natural resource management and governance is to define the system under investigation; i.e. which parts and processes of the SES to include. Deciding on the adequate boundaries of the system and the actor network to be studied is a challenging endeavor. Within the field of SNA identifying appropriate boundaries entails theoretical as well as methodological considerations (Bodin and Crona, 2011). From a theoretical standpoint, the boundary is to a large degree defined by the overarching research question and the applied theoretical framework. Methodologically it is vital to employ appropriate techniques and approaches for identifying the relevant actor set and the most important pattern of interactions pertaining to the research question (Borgatti et al., 2013).

Two different ways of specifying network boundaries are commonly used in SNA. The nominalist approach "is based on the theoretical concerns of the researcher" (Wasserman and Faust, 1994: 32 referencing Laumann, et al., 1989). The realist approach, on the other hand, "focuses on actor set boundaries and membership as perceived by the actors themselves" (Wasserman and Faust, 1994: 31 referencing Laumann, et al 1989). Rather than viewing the two approaches as incompatible, they are often combined to allow for a more accurate identification of the network boundary (Marin and Wellman 2011; Borgatti et al., 2013).

While the criterion that all relevant organizations had to be involved in the management of the Berg catchment is more consistent with the nominalist approach, this study placed greater emphasis on

regional economy conducted by Daan Louw estimates that the loss in value-added could be as much as R735 million, which equates to a loss of 60% market share (Louw, 2008).

[68] Most affected are people living in informal settlements as they are the ones exposed to the contaminated water and water borne diseases due to lack of basic infrastructure.

the realist approach for identifying the network boundary. The realist approach ensure that important actors and ties are not ignored in the study. It does so through a focus on self-reported ties that actors have to identify with each other. The approach is particularly applicable for actor sets characterized by fuzzy boundaries, a situation that can be observed in the present case. Given that South Africa's water governance system is currently transforming, having a formal mandate for water management in the Berg catchment does not imply that this organization is indeed actively involved in the management of the catchment. The lack of capacities or incentives may prevent an organization to from doing so. At the same time, an organization not formally linked to water management may play a critical role in some management activities either directly (e.g. through monitoring) or indirectly (e.g., through the provision of scientific ecological knowledge or incentive structures). It is therefore vital to look beyond formal jurisdictional arrangements, organizational boundaries and hierarchies. This was accomplished in this study by asking all organizations to identify those who are part of the network. Hence, all survey respondents were asked to mark those organizations on the recall list that they perceived as being active in the management of the Berg River. This was complemented by an additional measure: An organization was considered to be part of the Berg management network if it received at least two confirmations[69], and had regular collaborative interactions with at least one other organization from the network.

4.4.2. The SNA survey: design & execution

The relational data of the Berg management network was generated through a tailored survey that was conducted as part of face to face interviews. The structure and design of the survey was based on established approaches (Ernstson , 2008; Stein, 2010) and builds on the understanding of the catchment gained during the preliminary study.

4.4.2.1. The Pre-study

The aim of the pre-study was to gain a better understanding of the characteristics of the Berg catchment and to aid the development of the SNA survey as well as the creation of the recall list. Through the pre-study relevant organizations and practices as well as dominant issues relating to the management of the Berg River were identified. In this process, key individuals from different sectors (such as conservation, agriculture, provincial and local government, research and consultancy) were interviewed and asked to name all the organizations that they believe are active in the management of the Berg catchment. A total of 13 individuals were interviewed.[70] In addition relevant policy documents (e.g. Berg WMA: Internal Strategic Perspective 2004) such as existing reports (e.g. River

[69] More specifically, at least the 2 other organisations had to verify that they interact with tat specific actor on a regular basis.

[70] Appendix 4.6 provides the complete list of interviewees.

management strategy for the Berg WMA of Western Cape Scoping Report Oct. 2008 , Berg River baseline studies 2007, Berg River water quality task team report 2009) and previous studies (e.g. Gueze and Jonker, 2008).were reviewed.

4.4.2.2. The SNA Survey

The survey was organized in three parts and entailed relational as well as context specific questions. Another central component of the survey was a recall list. Such a list is commonly used by social network analysts as a robust method of generating network data on established patterns of interactions (Marsden, 1990). The recall list contained the names of all relevant organizations and also includes adjacent empty columns in which the respondents could mark their relations to the other organizations. In this way a recall list assists respondents to provide information about the interactions they may have with the other organizations mentioned on the list (Wasserman and Faust, 1994). Based on the findings from the pre-study a recall list containing the names of 57 organizations was created in this study. At the end of the recall list, space was provided for the respondents to add names of additional organizations that they considered important but that had not been mentioned on the recall list.[71]

Section one of the survey, which was used in conjunction with the recall list, contained questions about the respondents' relations to the other organizations operative in the catchment area. Section two elicited information on key characteristics of the respective organization (actor attributes). The third section had the intent to get a better understanding of the quality of the relations as well as to gain insights into how issues of water quality have been framed and responded to. The complete survey with all questions can be found in Appendix 4.1.

The SNA survey was conducted over an 8 months period from February 2011 to September 2011. All surveys were carried out by the researcher. The average interview was 1.5 hours with longest being 4 hours. Carrying out the survey as part of personal interviews reduced the risk that the interviewees would misinterpret questions or leave out important information. It was also important that the two terms, information exchange and collaboration, be discussed first before turning to the specific questions. Prior to each survey interview all respondents were made aware of their right to not participate in the survey and verbal consent was requested. The researcher also showed examples of visualized network graphs to the respondents to illustrate the output of this research and provided a lengthy explanation about the usage of the data collected by the study.

[71] See Appendix 4.2 for the recall list.

In order to create a better understanding of the manner in which actor relations enhance or hinder AM in regional SESs, the organizations were asked to report on their collaborative relationships. Two relationships were investigated in greater detail through the survey:

- *regular information exchange among the organizations on the issue of degrading water quality and the environmental status of the Berg River*
- *regular collaboration among the organizations on the issue of degrading water quality*

The two relations were chosen because they capture information flow, and the coordination as well as integration of practices and institutions among the organizations. More specifically, the level of horizontal cooperation in the network was investigated through these two relations. The focus was on finding evidence of cooperation and coordination among core WMOs, the formation of collective action initiatives, the integration of ecological knowledge, as well as the representation of different sectoral interests and needs.

The reason for making a distinction between information exchange and collaboration is based on the assumption that each relation demands quite different levels of engagement from the organizations. While information exchange can be performed quite informally, collaboration demands that a greater part of the organization be involved, and often an organizational decision needs to be taken prior to venturing into collaboration with others (Ernstson et al., 2008). Additionally, collaboration tends to institutionalize a certain pattern of interaction. For example, Schneider et al. (2003) highlight that collaboration between two organizations creates mutual knowledge about the workings of each organization, and administrative and contractual agreements that can be re-used, making the next collaboration more effective. Thus, one could assume that collaboration, since it is more demanding, should have a greater influence on the structuring of the network as compared to information exchange.

In order to better understand how actor attributes may impact network dynamic and to be able to test some assumptions, data on specific characteristics of the organizations was included in the analysis. These include:

- Type of organization;
- Sector;
- Mode of governance;
- Mandate for managing water resources;
- Type of ecological knowledge that an organization posses, focus has been on sources of scientific ecological knowledge and experiential ecological knowledge;
- Dependency on water from the Berg;

- Scale of activity: upper catchment , lower catchment, outside catchment, whole;
- Type of WQ issue addressed by the organization (alien or pollution.

4.4.3. The Analysis and interpretation of the network data

All network data (relational as well as attribute data) generated through the SNA survey was first captured in an Excel spreadsheet. The relations were recorded in Excel by creating 54x54 square matrices. The matrix format was also used for handling the attribute data. For each attribute a numeric coding system was created. These attribute matrices contained 54 of rows and 1 column for the specific attribute. The data sets were then analyzed with the help of UCINET (Borgatti et al., 2002) and NetDraw (Borgatti, 2002). The two programs are commonly used by network analysts for measuring specific network properties (UCINET) and for visually illustrating and interpreting (NetDraw) the network data.

To be able to reveal the underlying structure that supports the Berg management network only reciprocal ties among the organizations were considered in this study. That is, a tie had to be acknowledged by both organizations. A focus on reciprocal ties has the advantage that it reduces concerns related to reporting accuracy (Marsden, 1990; Wasserman and Faust, 1994) and also directs the focus towards the stronger and more stable pattern of interaction in the network[72]. For most analyses the two network relations, information exchange and collaboration were combined into one single multiplex network. The reader is referred to Appendix 4.3 for a detailed explanation on how the final reciprocated network N was created.

Chapter 3 Section 3.1 discussed in great length which network measures have been employed to describe and analyze the structural properties of the Berg management network. In this context, it was explained how the two network characteristics, cohesion and heterogeneity, are assessed with the aim of providing a better understanding of whether the existing horizontal integration in the Berg catchment is conducive to AM.

The interpretation of the quantitative data of the identified network was aided by qualitative data from interviews, participant observations, workshops and document analysis performed between 2009 and 2012. This information created a better understanding of the nature of network relations, the role of individual actors, as well as expressions of self-organization and collective action. The qualitative data also helped to validate the quantitative network data.

[72] Granovetter (1973) for example points out that one indicator for tie strength is reciprocity.

4.4.4. Challenges for generating and analyzing network data

Several methodological problems may arise in the generation and analysis of social network data which can impact the validity and the reliability of the network data. A social network analyst needs to be aware of potential pitfalls and take measures to avoid or at least minimize them. The following section will summarize how issues such as missing data and informant accuracy were addressed in this study.

Network data that is missing, but also to the inclusion of data that is not valid, will ultimately lead to the misinterpretation of the network (Borgatti et al., 2013). Missing data can either arise because the network was incorrectly specified (i.e. a boundary issue) or because relevant actors refuse to participate in the study. The in-depth pre-study and the combination of the realist with the nominal approach enhanced the potential of accurately specifying the network boundary and therefore the actor set. Conducting the survey as part of personal interviews led to a high overall response rate of 88%, and ensured that in most cases all sections of the survey was completed. The measures that were taken to reduce the negative impact of missing data from non-respondents has been discussed in Appendix 4.7. A whole, these steps provided the basis for generating robust relational information on the organizations operative in the Berg catchment.

Informant inaccuracy resultant from the way in which questions are phrased and from the differences in perceptions of respondents with regard to the relations they have to one another (Marsden, 2005). In order to ensure that survey questions were phrased correctly and did not lead to any confusion the survey was tested prior to its finalization on one key informant and one colleague of the researcher. Further, the personal interactions with the respondents during the administration of the survey made it possible for the researcher to clarify any questions.

In this study, the respondents were specifically asked to only report on regular interactions relating to the management of the Berg River. This focus on more routinized interactions increases the reporting accuracy as people tend to report more accurately on regular interactions as compared to than sporadic interactions. Focusing the greater part of the analysis on reciprocal ties, also minimized the problem of the accuracy of information given by the respondents. Reporting accuracy was also strengthened by focusing on reciprocal ties, so that both actors had to confirm their relations which each other. Follow-up interviews were carried out in cases where there was a big discrepancy in the answers relating to the relations that two actors had with each other.

Prell (2012) states that the validity of the data is largely determined by the research questions through which we attempt to measure the network under investigation are the questions able to capture the notion of horizontal cooperation? The focus on collaborative relations, which include

information exchange, has been based on the assumption that they are expressions of horizontal cooperation. Chapter 3 discussed in greater detail why and how the two network characteristics of cohesion and heterogeneity were linked to the concept of horizontal cooperation.

Before concluding the section on the SNA it is important to respond to one of its commonest criticisms. It is often claimed claim that an SNA only captures a static view of the network; or that it can only provide a snapshot at a fixed point in time of social processes that are dynamic and changing. However, it is important to point out that the structures which determine the functioning of the Berg River management network do not change easily even if certain properties or positions in the network may change. As mentioned in Chapter 3, all relations come at a cost; it is not easy to establish and maintain new relations

4.5. Qualitative methods and data generation techniques

Although SNA forms a key method (and theoretical framework) for analyzing actor relations on its own, it is an insufficient tool for answering the stated research question because it cannot explain the external influences or drivers that shape horizontal cooperation in regional SESs. For this reason, the study includes qualitative methods namely semi-structured interviews, focus groups and participant observation and the collection and analysis of policy documents and other written material (e.g., minutes and agenda of past meetings). These qualitative methodological techniques are of significance to this study as they are "oriented towards analyzing concrete cases in their temporal and local plurality, and starting from peoples expression and activities in their local context" (Flick, 1998: 13). Table 4-1 provides an overview of the different qualitative research techniques used in this study.

Table 0-1: Overview of the qualitative research techniques

Technique	Stage of utilization	# of actors	Purpose
Semi-structured interviews	Pre-study	13	• Identification of relevant actors for recall list • Informed SNA Survey
	Collective action initiatives	35	• Understanding forms and outcomes of collaboration within and across the selected initatives
	SNA survey (Open questions SNA Survey)	51	• Greater clarity on actor relations and on relation to the river
Participant observations- public stakeholder meetings	Water Indaba (2) Stakeholder meetings organized by DWA Western Cape (3) Stakeholder meetings organized by DEA&DP (2)	n/a	• Interactions of the different stakeholder groups, • who attends such meeting and how are interests and needs voiced
Participant observations - Inter-organizational platforms	Adopt a River Stellenbosch (3) Berg Management Estuary Forum (4)	10 to 20	• How actors addressing a rinsing issues, prioritize activities and deal with conflicts among the members
Focus groups	Alien Clearing workshop Champion workshop	16 9	• Identification of constraints to catchment-wide collective action
	DWA Western Cape DWA National	3 3	• Barriers to the transformation of South Africa's water governance system as perceived by DWA • Constraints within DWA
Berg catchment video	Representatives from municipalities, IBs, retailer, CapeNature, Emerging Farmers, Researchers	6	• How different stakeholders describe their relation to the Berg River

Semi-structured interviews were an important research technique throughout the entire field work period (2010-2012) because they provided the freedom to explore emerging topics "while ensuring at the same time that all relevant themes are covered and all necessary information is collected" (Corbetta, 2003: 270). Focus groups is an interactive technique that was used to generate in-depth information on how the organizations perceived the functioning of the catchment and to identify major constraints to effective water management. Furthermore, the relatively informal and open-ended discussions that took place within the focus group settings allowed the respondents to explain in their own words the current state of water governance in South Africa. The dynamics of the discussions resulted in insights that would not have emerged in individual interviews. Two focus group meetings formed part of two workshops which had been organized by the researcher and her colleague on the topic of alien invasive vegetation and current and future threat to water security in

the Berg catchment (See Appendix 6.2). Another set of structured focus groups targeted representative from DWA national and DWA regional office (Western Cape).

Participant observation was used at public meetings that concerned water management in the Berg catchment. These events included among others, public stakeholder group meetings initiated by the DWA or DEA&DP. In addition, the researcher attended the membership meetings of inter-organization forums that were created with the aim to address specific management issues in the catchment. This allowed the researcher to observe common social practices that occur in the network. It was especially interesting to observe how the organizations interact and how they communicate their interests and concerns to others. Participant observation also served as a check to ensure that the findings of the SNA survey correspond with the observed interactions (e.g. do actors identified as holding central positions in the network lead the group discussions?). As Flick (1998) writes, the observed spontaneous activities and statements that the researcher witnesses during participant observations may be more reliable than responses to the researcher`s questions in the semi structured interviews or focus groups. The researcher is aware that the attempt to observe events as they occur might be compromised, since the presence of the researcher at those events may influence the behavior of the actors. However, as most of these observations took place in public settings, in which many individuals participate, the presence of the researcher would not seem so 'alien' to the observed community.

All qualitative data derived from semi structured interviews, observations and focus group discussions were recorded in field notes. Summary reports highlighting the most important discussion points and emerging themes were constructed after each round of data collection. In addition to the data collection methods mentioned above, the researcher also engaged in a detailed document analysis.

4.6. SNA specific ethical considerations

In order to protect research participants from harm, extra care needs to be taken when undertaking network studies. Borgatti and Molina (2003) highlight several ethical issues that need to be addressed in SNAs. They point out that "anonymity at the data collection stage is not possible" as the respondent needs to name the people with whom he or she has a relationship. Another issue is that of data display. More specifically, when seeing a diagram or graph, it is quite easy for respondents to identify themselves or others even if the names of the respondents are not disclosed (Borgatti and Molina, 2003). Yet, another concern is that in SNA studies data can be collected on people that are not included in the study, from whom no prior consent has been obtained (ibid.). Related to this is the issue of respondents providing data on people who decided not to participate in the study.

Finally, it is important to acknowledge that most respondents are not familiar with network analysis and the data it can reveal.

All of these ethical issues were addressed in the following manner: as mentioned above, the SNA survey was conducted through face-to face interactions. Prior to starting the survey the method of SNA was explained to each respondent. To aid the explanation a sample network graph was used to illustrate how the data is processed, displayed and what conclusions can be drawn from the data. After providing the respondents with a detailed description of the nature and content of SNA and the purpose and scope of the study, he or she could decide whether to participate in this study or not. All interviewees provided a verbal consent. They were also informed that they still had the option to stop their participation in the study at any given time. In addition, a letter outlining the research and its purpose was sent to each interviewee through email when the initial contact was created.

While it was not possible to grant the anonymity of the participating organizations, all names of the individuals representing the organizations were kept anonymous and the information that they provided has been treated confidentially. This was done by giving all respondents untraceable identification numbers. The data will be used for academic purposes only, and will not be shown to any other parties. Exceptions will be made for purposes of academic supervision and peer review.

5. Chapter: Assessing horizontal cooperation through a network perspective: network cohesion and heterogeneity in the Berg management network

5.1. Chapter Overview

This chapter analyzes horizontal cooperation at the operational level in South Africa's water governance system through a relational approach based on a network perspective. To achieve this aim, the chapter makes use of a formal SNA to characterize information flow and collaboration in the Berg management network. This enables the identification of opportunities and constraints for learning and collective action among the organizations that play a role in the management of the catchment's water resources. Several of the quantitative analyses are complemented by qualitative analyses of the nature of network relations, the role of individual actors, as well as expressions of self-organization and collective action.

Operative in a regional SES, the Berg management network[73] exemplifies the operational level of South Africa's governance system. In order to assess the functioning of the network, this study examines how the organizations have organized themselves in order to address the issue of degrading water quality in the catchment. The advantage of the network perspective employed in this study is that it is able to capture this multitude of actors and the complexity of their interactions, leading to a more holistic understanding of water management in the Berg catchment.

As described in Chapter 3, the understanding gained through a SNA can help explain how actor relations influence social processes (e.g., learning and collective action) and lead to specific governance outcomes (e.g., responses to water quality issues or the lack of implementation of the water reform). Based on the analytical framework developed in Chapter 3, and assisted by the quantitative relational data generated from the SNA survey, this chapter has the following objectives:

1. To identify the actor network involved in the management of the water resources in the Berg River catchment.
2. To assess horizontal cooperation based on the two network characteristics cohesion and heterogeneity;
3. To demonstrate how network cohesion and heterogeneity in the Berg management network influence learning and collective action among the organizations involved in the management;

[73]The organizations comprising the actor network operate at various localities and administrative levels and their engagement with water management differs widely. Yet their combined activities determine whether the state of the Berg River is kept within sustainable bounds so that human and ecological needs are satisfied.

4. To explore if a relational approach can provide new insights into sectoral integration and the coherence of governance modes.

The chapter is structured in the following way: after a brief introduction of the relational data, a general overview of the overall composition and structure of the Berg management network is provided. Here the organizations that participate in the management of the catchment are introduced and initial statements of how they relate to each other are made. This is followed by detailed analyses of the two network characteristics of cohesion and heterogeneity, which are used as indicators for horizontal cooperation at the operational level. From a SNA perspective, cohesion refers to the interconnectedness between the different organizations, i.e., how well connected they are. Heterogeneity refers to the diversity of actors involved in the network and the extent of cross-boundary linkages among them. Based on the argument put forward in Chapter 3, it is assumed that cohesion among the organizations operative in the Berg catchment is of great importance to the mobilization and coordination of collective action. Cohesion is assessed by examining the interactions among the core water management organizations (WMOs). Additional information on the cohesion in the network is gained through the inspection of the existence of cohesive sub-groups in the network. These cohesive groupings reflect the strongest collaborative patterns of interaction in the network and give an impression of how the network has organized itself. They also provide initial ideas of where capacities are located in the network and the extent of sectoral integration and coherence of governance modes. Heterogeneity is evaluated through the examination of the participation of major water users and of stakeholder groups highly dependent on the Berg River in the management of the catchment. In addition, the embeddedness of ecological knowledge in the network is assessed, and cross-boundary linkages are explored in view of sectors and modes of governance. Finally, the chapter discusses the role and impact of influential actors in the Berg management network. The chapter ends by returning to the four objectives posed in the beginning of the chapter. Reflecting on the findings, plausible answers are provided as to why existing collaborative efforts in the Berg catchment have not resulted in effective management actions that address issues of degrading water quality.

Table 5-1 provides an overview of the different analyses, first introduced in Section 3.1. The table shows how these analyses relate to the two network characteristics cohesion and heterogeneity, which network of interest they concern, and what the intended aims of the specific analyses are. The findings for each analysis can be found in an expanded overview in Appendix 5.1.

Table 5-1: Overview of the specific network analyses and aims

(DWA = Department of Water Affairs, IBs = Irrigation Boards, core WMOs = core water management organizations, eco= ecological)

	Analysis	Method	Aim	Network
	Basic whole Network measures	Degree and betweenness centrality Density Centralization	To identify relevant actors and the level of interaction among them. To assess how well the network is connected and how power and exchange (info and resources) are distributed in the network.	Network N
COHESION	Attribute based sub-group analysis	Group density and centralization: a. Core WMOs vs. others b. Comparison of four groups: • the DWA • IBs/WUA • municipalities • No-WMOs c. Sub-population IBs • Visualized sub-graph • Ego network central actor d. Sub-population municipalities & DWA • Visualized Sub-graph • Ego network central actor	To assess the cohesion among core WMOs and their role in the network.	Network N
	Comparison information exchange and collaboration	Density and composition	To assess how the operational level self-organizes. To assess variation in mandated and non-mandated actors, administrative levels.	Information Network, 'Collective action' Network
	Cohesive sub-group analysis	Girvan-Newman Algorithm	To identify 'collaborative' clusters i.e. organizations that have self-organized into groups.	'Collective action' Network
		Group density and centralization	To examine the interaction across cohesive sub-groups insight into catchment-wide collective action.	Main component of 'Collective action' Network

		G-F Brokerage method (gatekeeper and representative)	To identify actors important for linkages.	'Collective action' Network without isolates
HETEROGENEITY	Core-periphery analysis	Core-periphery continuous function	To detect marginalized organizations.	Network N(v)
		Identification of eco knowledge sources • No. of ties from sources to other non-eco actors • No. of sources non-eco actors have direct access to (w/o considering the DWA)	To assess the embeddedness of ecological knowledge sources.	Network N(v)
	Cross-boundary linkages	E-I Index (modes)	To examine information exchange among modes of governance.	Information Network
			To examine collaboration among modes of governance.	'Collective action' Network
		E-I Index (sectors)	To examine information exchange among sectors.	Information Network
			To examine collaboration among sectors.	'Collective action' Network
		G-F brokerage roles of specific actors	To examine the role of individual actors in establishing cross-scale linkages for: inter sectoral integration, bridging of governance modes and connecting cohesive subgroups.	Network N

5.2. Composition and structure of the Berg management network: a first impression of cohesion and heterogeneity

The relational data that is discussed and analyzed in this chapter was generated through a SNA survey which was carried out in the form of interviews (containing a structured questionnaire) from February 2011 to September 2011.[74] For a detailed discussion on the choice of organizations and the network boundary, the reader is referred to Chapter 4.

In total, relational data from 54 of the 58 identified organizations, which actively participate in the management of the Berg River, was collected, giving a response rate of 88%. This is a sufficiently valid data set that captures to a great extent relational information on the operational level in the Berg catchment. Since the survey respondents were able to add any organizations that the original recall list may have missed, it is assumed that the final actor set represents the most relevant organizations and their collaborative interactions relating to the management of the Berg catchment.

A network analyst can gain more clarity in complex governance settings by specifying and using the relations that are presumed to connect the most relevant organizations in a specific governance context. As stated in Chapter 4, in this study, two collaborative relations were investigated in greater detail through the SNA survey:

- **Relation 1 (Information exchange):** The regular information exchange among organizations relating to the issue of degrading water quality and the environmental status of the Berg River.
- **Relation 2 (Collaboration):** The regular collaboration among the organizations on the issue of degrading water quality.

For the purpose of this study, only reciprocal relations, i.e. those patterns of interactions that were acknowledged by both organizations, were considered. For most calculations, the symmetrical, binary, multiplex network N, which combined the two relations information exchange and collaboration, was used.[75] The valued network N(v) was used to identify the strong ties among the actors. These ties provided the basis for investigating the existence of cohesive sub-groups in the network. The reader is referred to Appendix 4.3 for a detailed explanation on how the relations were

[74] Chapter 4 provides detailed information on the development and implementation of the survey instrument. Appendix 4.1 and 4.2 lists the survey and the recall list.

[75] The two relations were combined into a single (multiplex) network through linear combination of their adjacent matrices (N(v)=INFO +COLL), which was then dichotomized to a binary network N with all values greater 0 becoming 1.

combined. Table 5-2 specifies which analyses were done in which network and how the networks are referred to in the chapter.

Table 5-2: Overview of the various networks used in the SNA analysis.

Network	Referred to as	Measurements
Multiplex Network N: symmetric, binary	Berg management network	• Whole NW measures: density, centralization, Degree and betweenness centrality, distance measures, • group density • G-F brokerage analysis
Multiplex Network N(v): symmetric, valued		• General composition • Core-periphery analysis
Information Network: symmetric binary	Information exchange	• E-I Index Sector and Modes
'Collective Action' Network: symmetric, binary	Collaboration	• Cohesive sub-group analysis • Group density • G-F brokerage analysis • E-I Index Sector and Modes

Figure 5-1 is a graphic representation of the Berg management network and shows a diverse actor set of 54 organizations that are actively involved in the management of the Berg River catchment. The graph conveys that all organizations are either directly or indirectly connected through collaborative relations. In other words, the Berg management network is a fully connected network comprising one component without any disconnected groupings or isolated individual organizations. This implies that theoretically every organization can reach all others. Of the 312 ties that link the organizations, 122 connect actors that exchange information as well as collaborate with each other. The remaining 190 ties refer primarily to information exchange ties only.

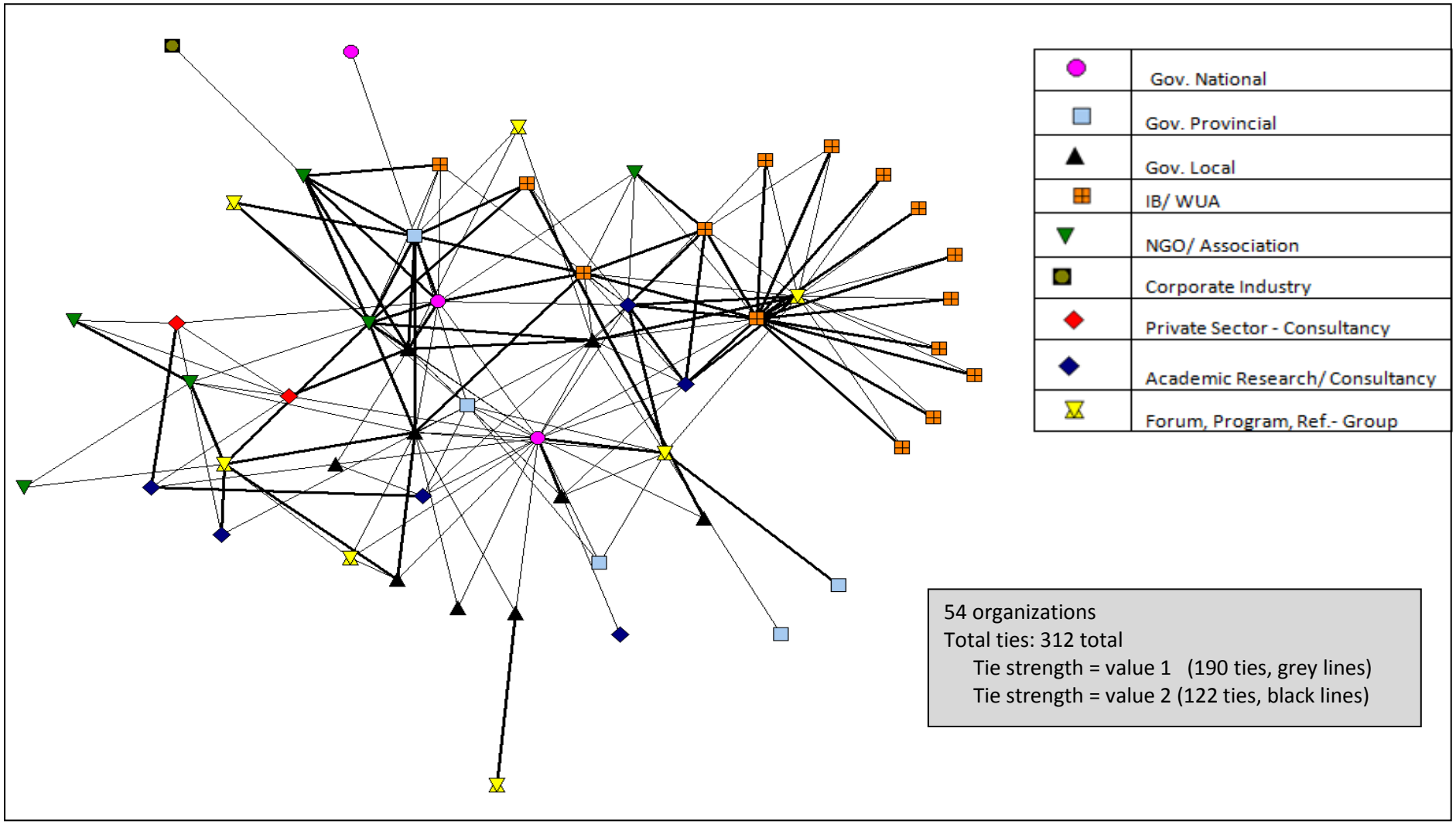

Figure 5-1: The Berg management network N(v)

The symbols show which organizational type each node (i.e. organization) represents and the thickness of the lines (i.e. ties) connecting the nodes indicate the tie strength. A value of 1 means that the organizations either exchange information *or* collaborate and a value of 2 means that they exchange information *and* collaborate.

The survey further revealed that 23 of the 54 organizations are engaged in river management without having a legal mandate that would obligate them to do so (See Figure 5-2). This suggests a certain level of voluntary engagement on part of some organizations, or at least the presence of incentives. Of the 31 organizations that have a formal mandate with regard to the management of the catchment, 24 organizations have a mandate for water management, the other organizations have mandates more specific to land management or environmental conservation. The 24 organizations with a mandate for water management are from here on specified as core water management organizations (WMOs). Also notable is the significant number of consultancies (six in total). A great surprise was to find a retailer among the organizations in the network. While this organization occupies a peripheral position, the qualitative data revealed that the retailer's engagement had a lot of potential to make positive contribution to the management of the Berg River.

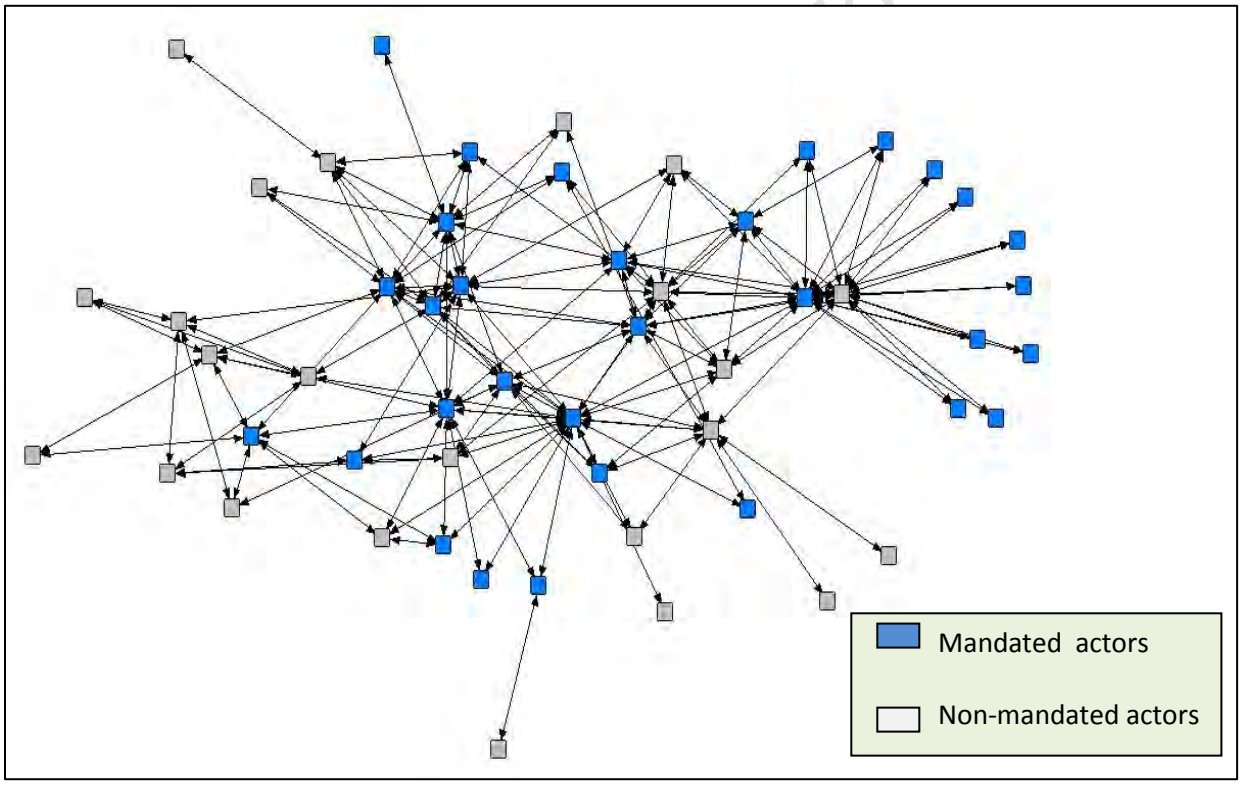

Figure 5-2: The Berg management network N(v): mandated (blue nodes) and non-mandated organizations (grey nodes)

The organizations that comprise the actor set vary substantially in their level of formality as well as organizational structure. In addition to the 47 organizations which have more permanent and formalized structures (such as government departments and NGOs), seven inter-organizational platforms (e.g., specific forums or reference groups), which tend to be more fluid and temporary, are

also part of the actor set.[76] Capturing the different organizational forms in the network made it possible to detect that some organizations are in more than one way engaged and represented in the network. For example, the West Coast District Municipality is an actor in the network, however it is also a member of the Berg Estuary Management Forum. Inter-organizational platforms such as the Berg Estuary Management Forum cannot just be represented as links between the organizations but constitute a node (actor) in the network as this platform has a collective purpose that goes beyond the objectives of the individual organizations.

Table 5-3 lists different administrative levels (national, provincial and local) to which the organizations involved in the catchment belong. While there is a significant number of national organizations, they all have a physical presence in the province, with several of them having their headquarters in the Western Cape Province. Not surprising is that local actors make up of 60 % of all organizations. It is notable that the majority of inter-organizational platforms are local initiatives.

Table 5-3: Administrative level of the organizations

Administrative level	Type of organization	Total #
National	2 government departments 1 national program 1 corporate -retailer 3 NGOs (WWF, WESSA, Bird Life) 2 research institutions 1 consultancy (Aurecon)	10
Provincial	5 government departments 3 NGOs 2 consultancies 1 inter-organizational platform (WQ team)	11
Local	14 IBs 1 WUA 7 local municipalities 2 district municipalities 3 consultancies (Wright, JB) 6 local inter-organizational platforms	33

Table 5-4 displays several network measurements that give a first impression of the cohesion among the organizations that compose the Berg management network. Of the 2862 possible ties, 312 are realized in the symmetrized binary network N. Although only 10,9% of the possible ties in the Berg management network are realized, the greatest steps (maximum distance) between any two organizations was five, with the average step (average path length) between any two organizations being 2.546. For a network of this size, one can still speak of a sufficient level of reachability among

[76] The names of the organisations and the Abbreviations used for their identification can be found in Appendix 5.5.

the organizations. The relatively high level of the centralization score of 29.83% suggests that the network may contain central but also several marginal organizations. The variances in the centrality scores, which are provided in Appendix 5.2, confirm this presumption. The betweenness centrality score also suggests that some organizations occupy positions that allow them to operate as gatekeeper or broker in the network. Hence, they can create linkages among organizations that otherwise would not be connected to each other.

Table 5-4: Descriptive statistics of the Berg management network (N)

Size = total number of organizations; Density = observed number of ties as a proportion of the total number of possible ties based on the network size; Degree centralization= a measurement of variation in the number of ties an actor possesses. Betweenness centralization= a measure of variation in the number of times organizations sit on the path between two other organizations. Diameter= greatest number of steps between any two organizations in the network; Average path length= average number of steps between any two organizations in the network. Average degree= average number of ties organizations have in the network.

Size	Density	Degree centralization	Betweenness centralization	Diameter	Average path length	Average degree
312	10.9%	29.83 %	28.09%	5	2.546	5.78

Table 5-5 lists the ten organizations with the highest scores for each centrality measure. In addition, the two graph representations of network N in Figure 5-4 visualize the degree centrality and the betweenness centrality scores of the different organizations (through the different node sizes). Based on the centrality measures, the network seems to be organized around two central organizations. The table and the graphs show that the Department of Water Affairs (DWA)[77] and one of the Irrigation boards (IBs) appear to be the most influential organizations it the network. This means these organizations have ties to many others in the network (degree centrality) as well as provide a link between many organizations that otherwise would be disconnected (betweenness centrality). That the DWA has the highest score of all organizations does not come as a big surprise given its regulatory role in water management. A valid interpretation of why the DWA has been able to obtain this favorable position in the network could therefore be its legal authority. Yet, if one looks at the other core WMOs (i.e. municipalities and IBs/WUA), this argument no longer applies. Significant variation within these two groups exists. The organizations that according, to their connectedness in the network, would have a significant amount of influence in the network are a forum, a consultancy, a conservation organization, and a provincial government department (see rankings in Table 5-5). This indicates that variables other than legal authority need to be investigated in order to better

[77]While a distinction must be made between the DWA national and the DWA regional offices (see Chapter 4 for a detailed explanation), the SNA showed that only the DWA regional office Western Cape is actively participating in the Berg management network. When the DWA is discussed in this chapter, the reference is mainly to the regional office located in the Western Cape.

understand why some of the organizations are more central and influential than others. Some of the subsequent sections intend to provide answers to which organizations occupy influential positions and whether these organizations are able to utilize their positions to advance the management of the Berg River.

Table 5-5: The ten highest centrality scores for degree centrality and betweenness centrality for the symmetric, binary network N

Gov =government organization, Gov (WMO)= governmental water management organization, Non-Gov (WMO) = non-governmental water management organization, Gov (Consv) = governmental conservation organization, Cons= consultancy

DEGREE			BETWEENNESS		
ID	Type	Score	ID	Type	Score
DWA	Gov (WMO)	21	DWA	Gov (WMO)	420.888
Main IB	Non-gov (WMO)	18	Main IB	Non-gov (WMO)	283.592
IB pollution	Non-gov forum	17	IB pollution	forum	158.610
Wright	Cons	14	WQ team	Gov (forum)	133.863
WCDM	Gov (WMO)	13	WCDM	Gov (WMO)	128.584
CapeNature	Gov (Consv.)	13	Wright	Cons	124.988
WfW	Gov	12	CapeNature	Gov (Consv.)	106.916
DoA_wc	Gov	12	WfW	Gov	101.241
DS_M	Gov (WMO)	12	DS_M	Gov (WMO)	97.165
DEA&DP_wc	Gov	11	DoA_wc	Gov	94.803

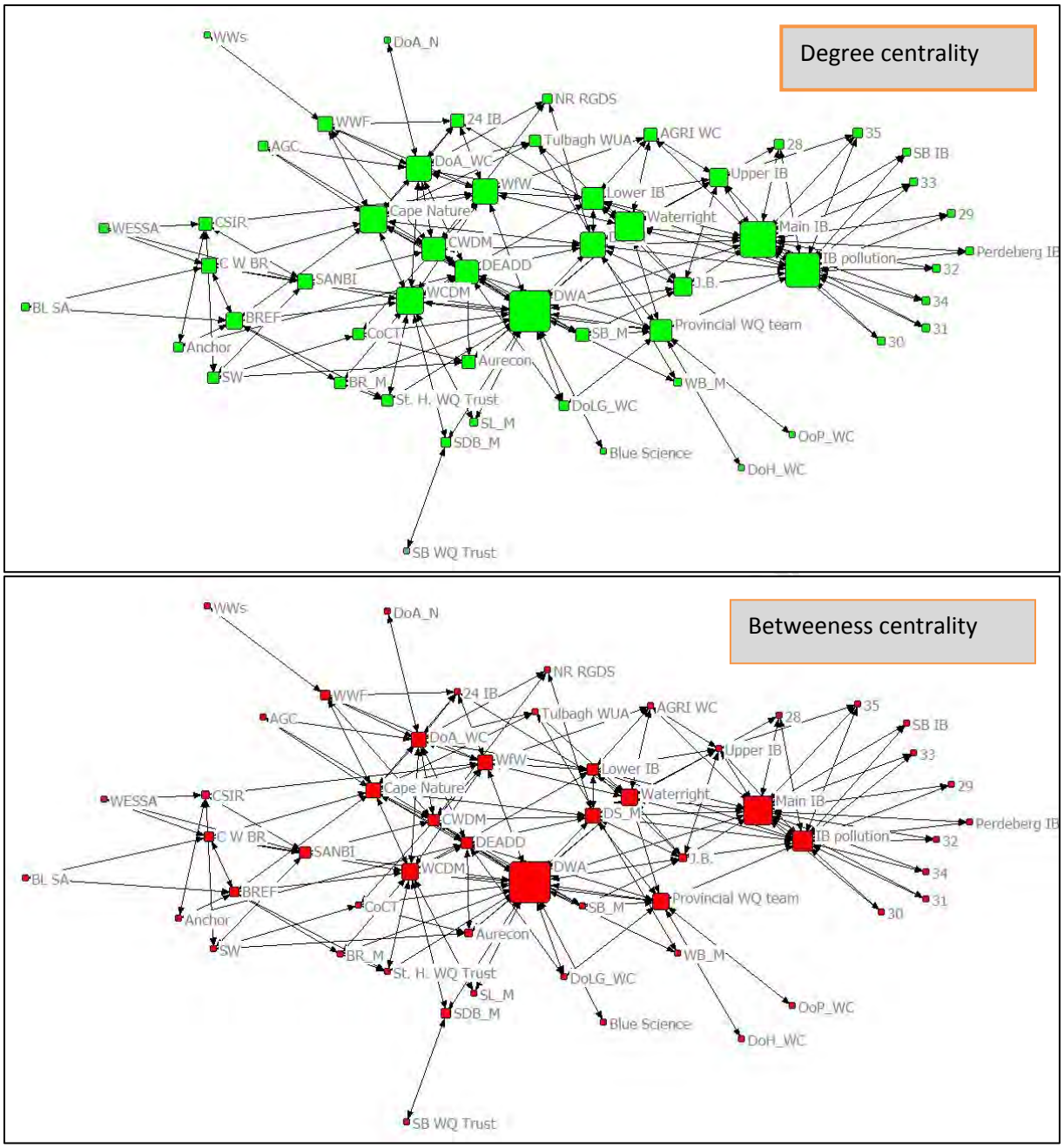

Figure 5-4: Degree and Betweenness centrality of the organizations

Actors with the highest score can be identified by the size of the note

The basic network measurements suggest that the Berg management network is quite heterogeneous in its actor composition (administrative levels, type of organization, mandated and non-mandated etc.). Indeed the wide variety of organizations involved suggests that the organizations could theoretically draw from a diverse set of resources (ranking from scientific ecological knowledge to technical know-how, to access to different decision-making processes, and to financial support). While the level of density is not especially high in the network, the rather short distances for information or resources to travel between organizations, and that no groups or organizations are isolated from the network, imply a certain level of interconnectedness among the

management network. Furthermore, the existence of several central organizations in the network may be of assistance in directing information flow and in coordinating collaborative efforts in the network. From this, one may expect ample opportunities for learning and collective action among the set of organizations.

Although these first exploratory network analyses reveal patterns of actor relations which should be supportive of collaborative management, they stand in sharp contrast to the realities that confront the Berg catchment. The degradation of water quality in the Berg River continues to be a prevailing issue and the qualitative data obtained from the preliminary study, the survey respondents as well as document analysis, suggest that water management in the catchment is of poor quality.[78] All of this indicates that the operational level is not functioning well. In order to understand the real extent of horizontal cooperation among the organizations, or the lack thereof, the cohesion and heterogeneity in the network needed to be assessed in more detail. Only then is it possible to draw any conclusion on how existing relations among the organizations impact their learning and collective action opportunities.

5.3. Cohesion: patterns of interactions among core water management organizations and the existence of cohesive sub-groups

This section provides greater clarity on the existing cohesion among the organizations involved in the management of the Berg catchment. All measures discussed in this section were done on the binary multiplex network N. The assessment starts by examining the interactions among three types of core water management organizations (WMOs), namely the DWA, the irrigation boards/ water user associations (IBs/WUA), and municipalities. The interest in the interconnectedness among the core WMOs (i.e. those which a specific mandate concerning the management of the Berg River) is based on the assumption that given their formal roles in water management, one would expect a significant level of information exchange and collaboration among those organizations. In this context, the interactions of core WMOs with other organizations from the network are also compared. This allows evaluating collaboration among the core WMOs and providing a first impression to what extent they also interact with other organizations. The analysis is complemented by an investigation into the extent to which the network has organized itself into cohesive sub-groups. A cohesive sub-group analysis provides a more accurate picture of the tie distribution in the network. It therefore enables the researcher to make an informed statement about how well the network is integrated as a whole (e.g. Prell, 2012). The analysis is also valuable in identifying those parts of the network that distinguish themselves from the rest of the network through their high internal activity (Hanneman

[78] See Appendix 5.4 for a list of survey respondents whose qualitative data informed the discussions below. Reference in text to the qualitative data is made through (Interview S-#).

and Riddle, 2005). Wasserman and Faust (1994:251) state that "cohesive sub-groups are theoretically important … because of social forces operating through direct contact among sub-group members, through indirect conduct transmitted via intermediaries or through relative cohesion within as compared to outside the sub-group". These 'collaborative' clusters (characterized by dense and strong ties) may in turn be expressions of collective action at sub-network level.

5.3.1. Exploring the collaborative interactions among core water management organizations (WMOs)

The National Water Act of 1998 has placed specific responsibilities on several organizations with regard to water management at the catchment scale. Of those organizations that are displayed in Figure 5-4, three types of organizations are of relevance for the analysis of the Berg management network. They are marked by red circles in Figure 5-5 and refer to the DWA (in particular its regional office in the Western Cape), several municipalities (local, district and metropolitan) which function as Water Service Authorities (WSA)[79] and in some cases also as Water Service Providers (WSP)[80] as well as IBs/WUAs. IBs are not displayed in the Figure 5-5 as they, according to the National Water Act, should have been transformed to WUAs (RSA, 1998). The reader is referred to Appendix 4.4 for a detailed description of the core WMOs and to Appendix 4.5 for a historically embedded overview of South Africa's water governance system.

[79] A WSA is responsible for the management of domestic and industrial water use. The main focus is on bulk water supply and sanitation services. The role can only be fulfilled by local or metropolitan municipalities (Schreiner and Hassan, 2010).

[80] A WSP is responsible for the practical implementation of water service provision. The municipality (WSA) can fulfill this role or it can contract another organization, e.g., a district municipality. Hence, WSPs don't need to be municipalities whereas WSAs have to be local or metropolitan municipalities (Schreiner and Hassan, 2010).

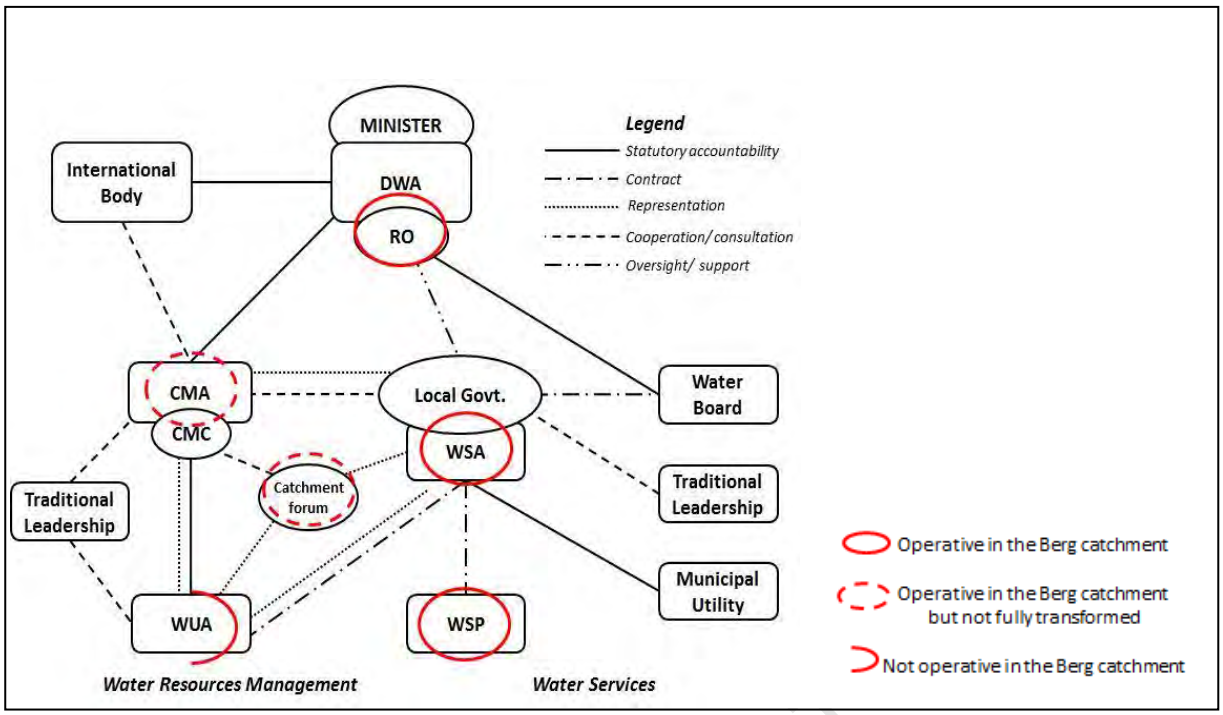

Figure 5-5: Core water management organizations and the envisioned relations among them

Adopted from Mazibuko, G. & Pegram, G (2006)

(The DWA = Department of Water Affairs, RO = Department of Water Affairs Regional Office, CMA = Catchment Management Agency, CMS = Catchment Management Strategy, WSA =Water Service Authority , WSP=Water Service Provider, CMC= catchment management strategy).

In the case of the Berg catchment, all IBs except one, which has been transformed into a WUA, still operate as IBs. The incomplete transformation of these organizations is expressed through the red half circle in Figure 5-5. Organizations that are marked by dotted red circles are WMOs that have been called for by the National Water Act (1998) but do not currently exist in the Berg catchment. They are a catchment forum and a catchment management agency (CMA). According to the National Water Act (1998), CMAs plays a critical role in coordinating activities within a catchment. Since the regional offices of the DWA are supposed to act as proto-CMAs in catchments where CMAs still need to be established (Herrfahrdt-Pähle, 2010), it is assumed that the collaboration among the other core WMOs should not be too constrained by the missing CMA in the Berg catchment. Important to note is that a catchment forum (the CMA reference group being representative of key stakeholder groups) existed from 2005 to 2007 in the Berg catchment (Interview S-1; Gueze and Jonker, 2008). The forum did substantial work on preparing the process for the creation of the CMA and the CMS (Interview S-1). However, the forum disintegrated in 2007 because of the realignment process within the DWA national (Interview S-1).

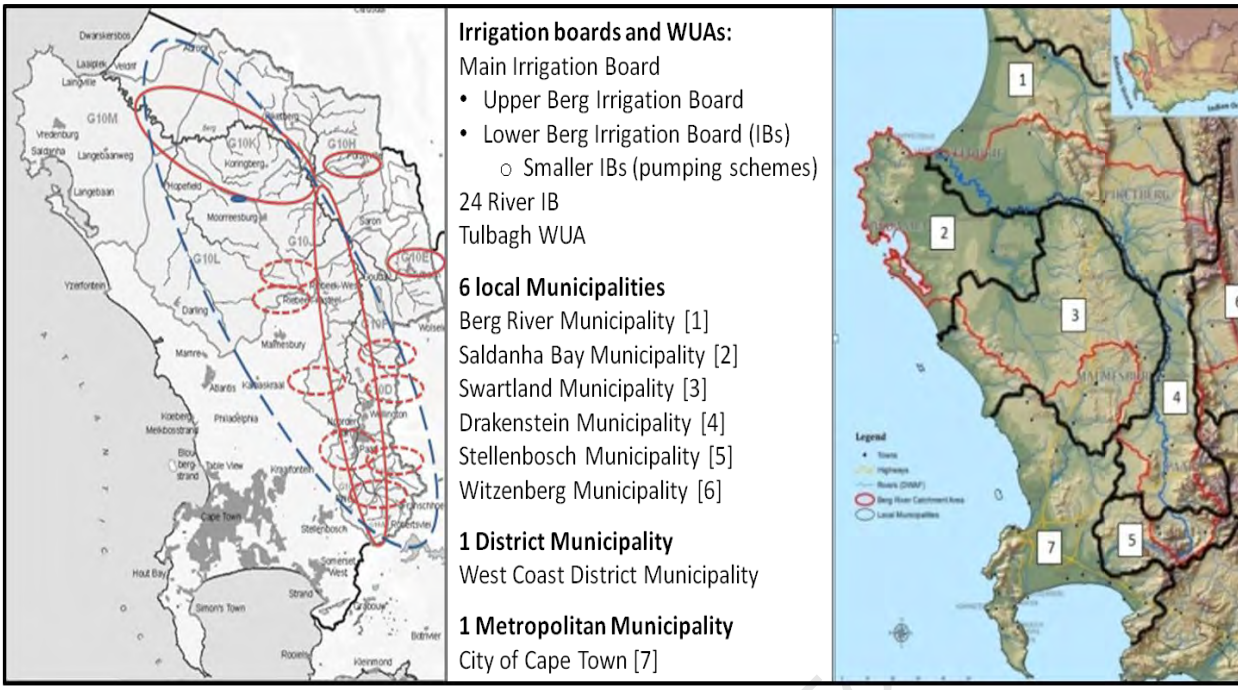

Figure 5-6: Geographic locations of core WMOs at the local level

The IBs/WUA are captured in the left map and the locations of the local municipalities are displayed in the right map.

Figure 5.6 shows two maps of the catchment that display the geographical locations of the IBs/WUA and the municipalities. The left map shows where the 14 IBs and the individual WUA are situated in the Berg catchment.[81] One can see that most IBs belong to an umbrella organization, the Main IB which is marked by a circle with a dotted blue line. Two organizations, the WUA and one IB are located at tributaries of the Berg River. The right map shows how the municipal boundaries relate to the catchment. The catchment is within the boundaries of six local municipalities. While Cape Town, a metropolitan municipality, is located outside the catchment borders, it receives a significant amount of its water from the Berg River and is consequently an important stakeholder (DWA, 2007). All of the six local municipalities act as water service authorities (WSAs); three of them also fulfill the role of water service providers (WSPs). The West Coast District Municipality (WCDM), for which boundaries are not shown on the map, is also formally involved in water management activities.[82] The WCDM is the WSP for Bergriver Municipality, Swartland Municipality and Saldanha Bay Municipality.

[81] Besides two larger IBs that are directly located along the Berg River, the others are small IBs that are not adjacent to the river. They receive their water from the Berg River through pumping schemes (Interview S-2).

[82] Part of the district municipality are the Bergriver Municipality, Swartland Municipality and Saldanha Bay Municipality as well as several other local municipalities located outside the catchment.

It is important to note is that while the DWA's responsibilities are primarily focused on water management and resource protection, the municipalities and IBs have quite a large number of other responsibilities that are not related to the water sector.[83] Yet, despite the differentiated prioritization of water management among the core WMOs, one would expect a strong level of interaction among the WMOs when compared to the rest of the network. If indeed regular communication linkages (expressed through many ties, i.e. high density) among the WMOs exist, then it also seems reasonable to think that the core WMOs will be likely to jointly address issues of degrading water quality.

To assess the interconnectedness and cooperation among the core WMOs, several measures were calculated in the multiplex network N. First, the three core WMOs were placed into one large group and the interaction among them was compared to the group of organizations representing the rest of the network. Then the group containing the core WMOs was divided into 3 sub-populations (the DWA, municipalities, IBs/WUAs). What remained was the sub-group containing all other organizations. The number of linkages between the four groups and within the four groups were measured and compared. This was followed by the examination of several relational properties that characterize the sub-population containing the municipalities and the sub-population containing IBs/WUA. Then, based on the observed patterns of interactions, opportunities for learning and collaboration within each group was evaluated.

5.3.2. Comparing cohesion of the core WMOs with rest of the Berg management network

Table 5-6 shows that both, the group of core WMOs and the group containing all other organizations (non-WMOs), have more internal linkages than external linkages. The density measures further reveal that the density among the 24 core WMOs does not differ greatly from the group density of the 30 non-WMOs. The same can be said about the reachability among the actors within each group. Reachability denotes whether information can be transmitted from one organization to another either directly or indirectly through intermediate organizations and the time it takes for information to travel i.e. a longer path equates to more time (Wasserman and Faust, 1994))If one compares the centralization scores in Table 5-7 then it becomes clear that the ties are actually more evenly distributed among the group of non-WMOs. With a centralization of 54.1% the group of the core WMOs appears to depend on a few central organizations for its cohesion. That this is the case becomes strikingly clear when one looks how the organizations are organized around two focal actors in the left sub-graph at the bottom of Table 5-7. The measures suggest that the interaction within the group of core WMOs is by no means greater than the interaction among the non-WMOs.

[83] Representatives of IBs are commercial farmers and their primary focus is on agricultural production. The municipalities on the other hand have to provide many other basic services to their constituencies.

Indeed information exchange and collaboration among the WMOs seem highly depend on the two central actors.

Table 5-6: Cohesion of core WMOs in comparison to cohesion of all other network actors based on density measures.

The scores on the diagonal are refer to intra-group tie density.

	Core WMOs	Non-WMOs
Core WMOs (n= 24)	0.124	0.099
Non-WMOs (n= 30)	0.099	0.112

Table 5-7: Key network measures to compare cohesion of core WMOs to cohesion of all other actors

	Core WMOs (n= 24)	**Non-WMOs (n= 30)**
Density	0.124	0.112
Centralization	54.1%	16%
Average path length	2.5	3.1
Diameter	5	6
Sub-graph		

5.3.3. Cohesion among and within the core WMOs

In Table 5-8, the group of core WMOs was further split into three sub-population in order to evaluate the extent of interaction among the core WMOs. The group of non-WMOs was also included in the analysis to show the extent of communication of the three groups to the non-WMOs. The density measures imply that the DWA interacts with all municipalities but that the interactions among the municipalities themselves are rather limited. Indeed, it is only the group of IBs/WUA that have more internal (0.133) than external ties. All other groups have more external than internal ties. Noticeable is the high centralization score for the group of IBs signifying the crucial role of one central actor (the Main IB) in this group. Limited exchange exists between the IBs and the local municipalities. If the

DWA is excluded, then the group of non-WMOs actually has on average more internal ties (3.6) than the core WMOs. While the municipalities have on average 0.75 direct ties, the IBs have on average 1.86 direct ties.

Table 5-8: Density and centralization between and within the core WMOs groups

The group of non-WMOs is included for comparison. The grey cells on the diagonal refer to intra-group tie density.

	DWA	Munici-palities	IBs/WUA	Non-WMOs	Centralization (%)	Average Degree
DWA (n=1)	-----	1.00	0.067	0.4	------	-------
Municipalities (n=8)	1.00	0.107	0.042	0.073	42.6	0.75
IBs/WUA (n=15)	0.067	0.042	0.133	0.073	83%	1.86
Non-WMOs (n= 30)	0.4	0.108	0.073	0.124	16%	3.6

When focusing on the sub-graph of the core WMOs in Figure 5-7, several observations can be made. The IB located in the left corner is completely disconnected from the other core WMOs. Furthermore, the graph appears to be divided into two clusters, with each cluster organized around one of the two central organizations. The color of the nodes indicate that the left cluster contains most of the IBs which are all directly linked to the Main IB. The cluster on the right includes the municipalities and is centered around the DWA. The WUA has no collaborative relations with the IBs and interacts on a regular basis only with a local municipality. The graph also implies that only the Drakenstein Municipality and the WCDM engage in regular interactions with some of the IBs (including the Main IB). Based on the qualitative data that was generated about the nature of relations, it appears that the Drakenstein Municipality and the group of IBs, through regular informal interactions (which started off highly confrontational), have been able to develop a more collaborative and trustworthy relationship. The engagement was initiated by the Main IB and later fostered through the chair of the IB pollution committee that forms part of the group of IBs.[84] The sizes of the nodes in the sub-graph represent the degree centrality score of each actor and highlight again the central role of the DWA and the Main IB among the core WMOs. Given their positions, the two actors actually have the possibility to act as gatekeeper or broker among the two groups as well as within their respective group.

[84]Through the regular informal meetings, both parties became aware of each other's needs and constraints, especially.the internal and external constraints that the specific municipal departments are faced with in the context of water service provision and management (Interview S-4).

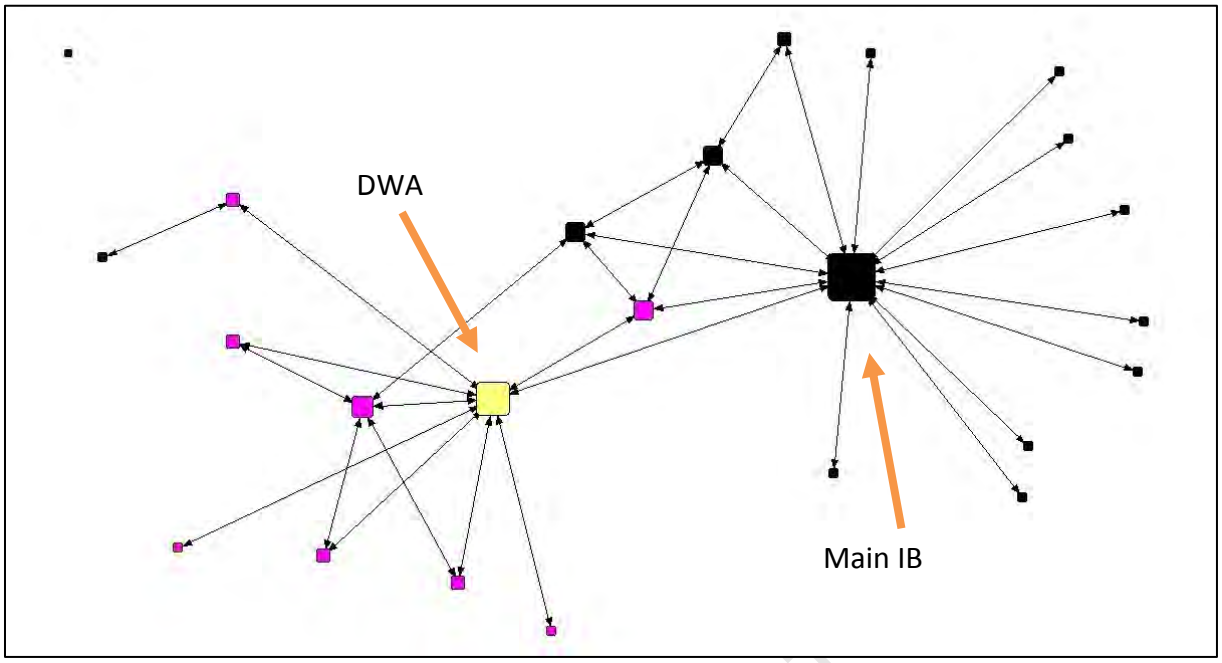

Figure 5-7: Sub-graph of the core WMOs

Pink nodes =Municipalities, black nodes =IBs/WUA, yellow node =DWA

5.3.3.1. *Relations between the IBs (sub-population)*

This section examines the collaborative relations among the IBs and describes how the observed collaboration is reinforced by the activities of the Main IB. Figure 5-8 shows the sub-graph of the IBs. Except for the two isolated organizations on the left the pattern of interactions display almost an ideal star-like network structure, with a few IBs forming triads.

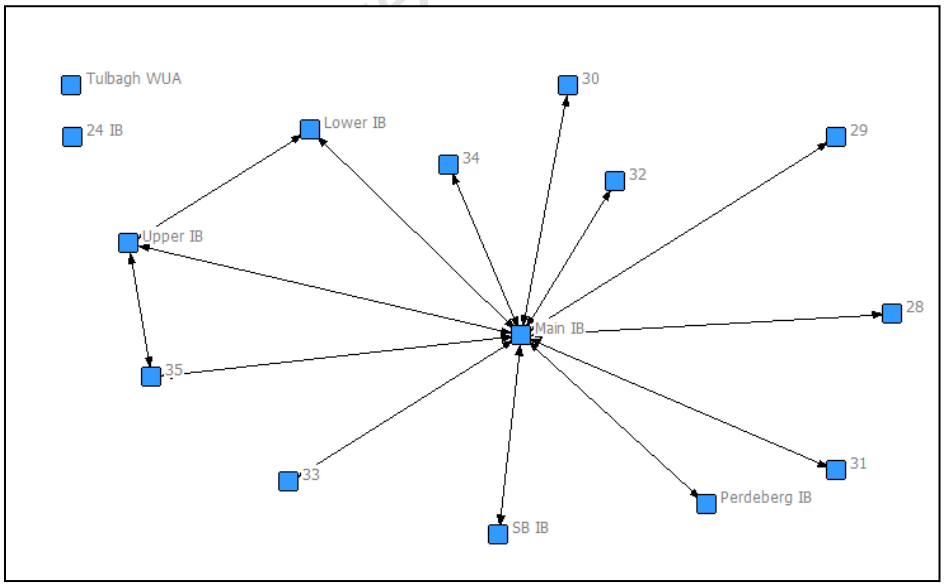

Figure 5-8: Sub-graph visualizing the sub-population of IBs and WUA

In the network literature, a star-like network structure is viewed as being optimal for the coordination and mobilization of collective action as it provides for quick information flow through the central coordinating actor (e.g. Borgatti et al., 2013; Ernstson, 2008). It enables the group of IBs to be well connected without all actors having to invest in a lot of relations (Ernstson, 2008). The triads in Figure 5.8 represent strong cooperation among the most important IBs in the group, namely the Main IB as well as the two IBs adjacent to the river (Lower IB and Upper IB) and the largest pumping scheme IB.

The investigation also highlights that just because the IBs belong to the same stakeholder group does not mean that they interact with each other on a regular basis on water management issues. Geographical location and the sharing of infrastructure systems seem to be contributing factors. For example, the reason as to why the WUA and one IB (the 24 River IB) are not connected to the other IBs is geographical. The two organizations receive their water from the tributaries of the Berg River. Therefore there is no need to have formal ties to the other IBs. Indeed, the IBs belonging to the Main IB are connected via formal relations which set the rules for water distribution among the IBs and their contributions to the maintenance of the infrastructure. However, the relations among the IBs go far beyond formal contracts. Many of the chairmen of the IBs have been neighbors for generation (Interview S-2). They are friends, business partners, and sometimes competitors on the agricultural market (Interview S-5). One of the main reasons why they decided to establish the Main IB was not to coordinate their internal affairs. Coordination among the pumping IBs was previously organized by the Upper Berg IB (Interview S-6). The Main IB, which is composed of chairmen of all IBs, was established to present to the political decision makers the interests and concerns of all IBs and their members along the Berg River.

To gain more legitimacy and to create political pressure, the IBs took their collaborative efforts even further. Under the Main IB they established a pollution task team committee (from here on the IB pollution committee) that includes representatives of the IBs as well as several experts.[85] With the information generated by the committee, the IBs have been able to provide evidence that the local municipalities in the upper catchment are some of the largest polluters. This has put pressure on some of the municipalities to engage with the IBs and to start discussing measures that could be taken to address the problem.

[85] The IB pollution committee meets on a regular basis to discuss emerging issues and to provide water quality information to the Main IB. (Interview S-4)

Figure 5-9 displays the Ego-network[86] of the Main IB which illustrates how well connected the organization is to its member organizations, to various experts that contribute to the pollution committee, and to political decision-makers.

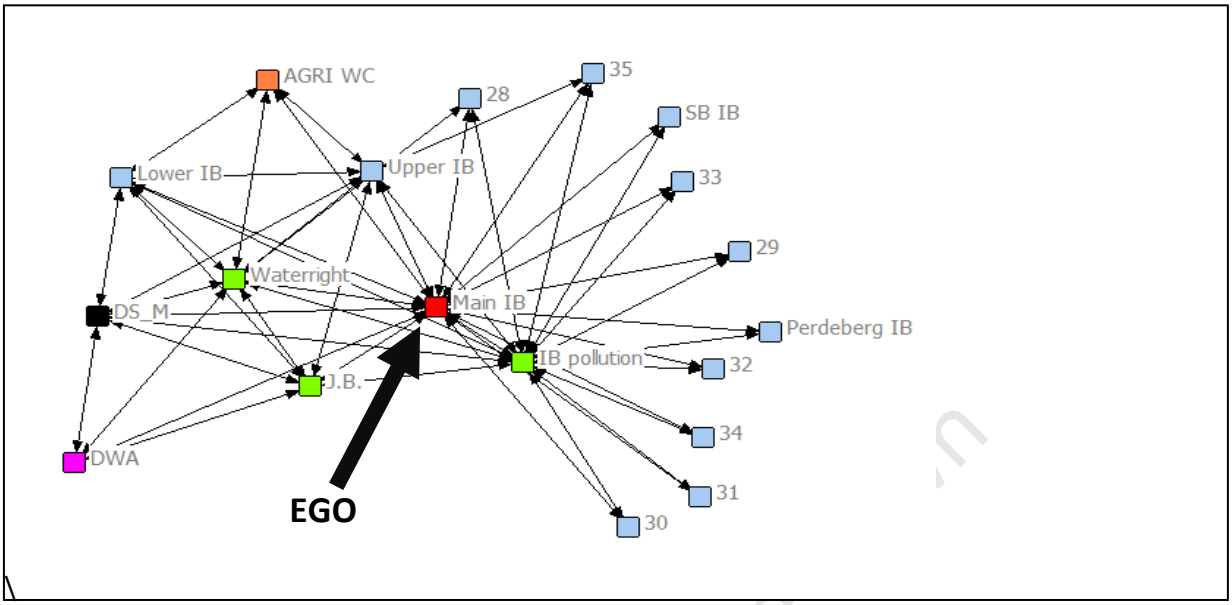

Figure 5-9:The Ego-network of the Main IB: Shows direct ties of the Main IB (red node) to important decision makers as well as experts participating in the pollution committee.

The qualitative data from the survey also support the impression that the IBs are bound together through trust relations. In the interviews all chairmen of the IBs said that they completely trust the Main IB with their external affairs and that they support any decision the Main IB makes. Some even went so far to say that they only view information on the Berg River provided by the Main IB as legitimate information as they neither trust information coming from DWA nor from the municipalities.

To summarize the investigation into the patterns of interaction among the IBs: A high level of cohesion, which is based on trust relations and maintained through one central actor, characterizes this group. The self-organizing capacity of the IBs (structurally explained by the star-like relational structure) allows them to mobilize internal resources which leads promptly to effective collective action (see Figure 5-8 and table 5-9). The creation of the IB pollution committee, for example, made it possible to establish important linkages to scientific experts and to lobby political decision makers at different administrative levels. By having access to valuable and legitimate knowledge concerning the river through the committee and a self-organized water quality monitoring system, the IBs are able to intervene in political decision-making processes concerning the river.

[86] Ego-networks consist of one focal actor (called ego) and the actors to whom ego is directly connected (e.g. Prell, 2011; Borgatti et al 2013).

Table 5-9: Major information exchange and collaboration activities within the group of IBs

Information exchange relevant to Water Quality	Collaboration
▪ Monthly reports on the WQ of the Berg sent by IB pollution committee to all member IBs ▪ Informal sms alert system in the event of a pollution incident ▪ Official meetings (twice a year) ▪ Quarterly meetings of Main IB ▪ Monthly to bi-monthly meeting of IB pollution committee	▪ Establishment of the Main IB to represent interests of all IBs to political decision makers ▪ Establishment of IB pollution committee to provide scientific evidence of the pollution in the Berg River and to lobby political decision makers ▪ Establishment of a water quality monitoring system covering most of the Berg (12 sites)

While the strong cohesion among the IBs has enabled them to become effective and competent actors in the network, the high internal cohesion may not always be beneficial. Although the IBs have access to different knowledge sources, most of the information gets filtered through the Main IB. Learning occurs primarily within IB pollution committee and is not necessarily diffused to the IBs as a whole. Indeed, the qualitative data supported the impression that currently most of the knowledge gained is used strategically to advance the interest of the IBs without having much impact on their own land and water management practices. This potentially negative effect of cohesion based on a star-like network structure on learning has also been observed in other studies. Ernstson (2008: 32) for example, highlights that such relational structure can in the "longer-term undermine social learning because it reduces the access of individual actors to multiple sources of information."

Furthermore, the strong cohesion among the IBs has reduced the freedom of the individual IBs to collaborate with other organizations from the Berg management network. The 24 River IB and the Tulbagh WUA, that have no regular collaborative relations with the other IBs, differ in their relational characteristics from those IBs that have organized around the Main IB. The Tulbagh WUA and the 24 River IB have collaborative relations with various kinds of organizations operative in the catchment. They are also more proactive on issues relating to alien invasive clearing activities in the catchment. The IBs belonging to the Main IB need to wait for the go ahead from Main IB before they can engage in any type of partnership or participate in specific activities relating to the management of the Berg River. One expectation is that the Lower IB is also engaged with WCDM on alien clearing issues. The reason for its greater freedom is related to the fact that until joining the Main IB, the Lower IB operated quite independently of all other IBs.

5.3.3.2. Relations between the municipalities (sub-population)

This section demonstrates that the patterns of interaction among the municipalities in the realm of water management differ strongly from those of the IBs. Before explaining the relations between the

municipalities, key characteristics of the local and metropolitan municipalities are summarized in Table 5-10.

Table 5-10 Key characteristics of the municipalities

	Municipality	Dependency on Berg River (water services)	Location	Impact	Population growth rate*	Importance of Berg River for	Collaborative WRM activities	Degree centrality (# of ties)
Lower catchment	Bergriver Municipality	High	Adjacent to Berg River, estuary	Abstraction and discharge	2.85%	Tourism Fishery	Estuary forum (mandated)	4
	Saldanha Bay Municipality	High	Lower catchment	Abstraction	3.49%	Domestic and industry	SD WQ Trust	3
	Swartland Municipality	High	Lower catchment	Abstraction	4.56%	Domestic and industry		2
	WCDM	Water service provider						**13**
Upper catchment	Drakenstein Municipality	Low to medium	Adjacent to River, upper catchment	Discharge	2.56%	Agriculture tourism	NRM resource group Individual WRM plan	**12**
	Stellenbosch Municipality	None	upper catchment	Discharge tributary (and main ?)	2.71%	Agriculture	Adopt a River	5
Mostly outside catchment	Witzenberg Municipality	None	Tributary	Discharge tributary	2.65%	n/a	WUA member (mandated)	2
	City of Cape Town	Medium to high	Outside catchment		2.57%	Domestic and industry		4

Source: expert interviews, SNA survey and Statistics South Africa (2011)

Table 5-10 highlights the fact that the municipalities differ in their dependency on the Berg River, their impact on the river as well as their demographic and economic constellations. These differences affect their relation to the river, their willingness to contribute to its management, and the willingness to collaborate with others. This becomes apparent when looking at the last column in Table 5-10. The degree centrality scores indicate the level of engagement of each municipality in the network. It shows that only the Drakenstein Municipality and the WCDM participate pro-actively in the network. Interestingly, the municipalities that are most dependent on the river for their water security (primarily the municipalities located in the lower catchment and the City of Cape Town) are not well embedded in the network. Despite the differences mentioned in Table 5-10, the local municipalities face similar challenges regarding the maintenance and upgrading of waste water treatment plants. Population growth, the pressure to provide basic services to poor communities, limited budgets, and corruption, are all factors that constrain the capacities of many South African municipalities to manage their water service infrastructure and operations sustainably. The qualitative data from the survey indicates that in addition to not having adequate financial resources, the municipal water service departments, which are primarily responsible for water management within the municipalities, lack the required human resources to fulfill their water services functions (Interviews S-8, S17, S-7, S-11). Expertise (e.g., environmental officers or department) for water management beyond water services is, in most of the local municipalities, non-existing (expectation Drakenstein Municipality).

With many problems in common, close interaction and the sharing of information and knowledge could be of benefit to these resource-constrained organizations. The quantitative analysis of this group shows that there is surprisingly little interaction (information sharing and collaboration) between the municipalities. The left sub-graph in Figure 5-10 visualizes that no direct patterns of regular interactions exist among the local municipalities in the realm of water management. It is only the three local municipalities from the lower catchment that are indirectly connected to each other through the WCDM. However, the sub-graph on the right in Figure 5-10 reveals that when the DWA is added, then the highly fragmented group of organizations becomes one complete network in which all organizations are indirectly linked. This means that information sharing and communication among the local municipalities is highly dependent on the DWA.

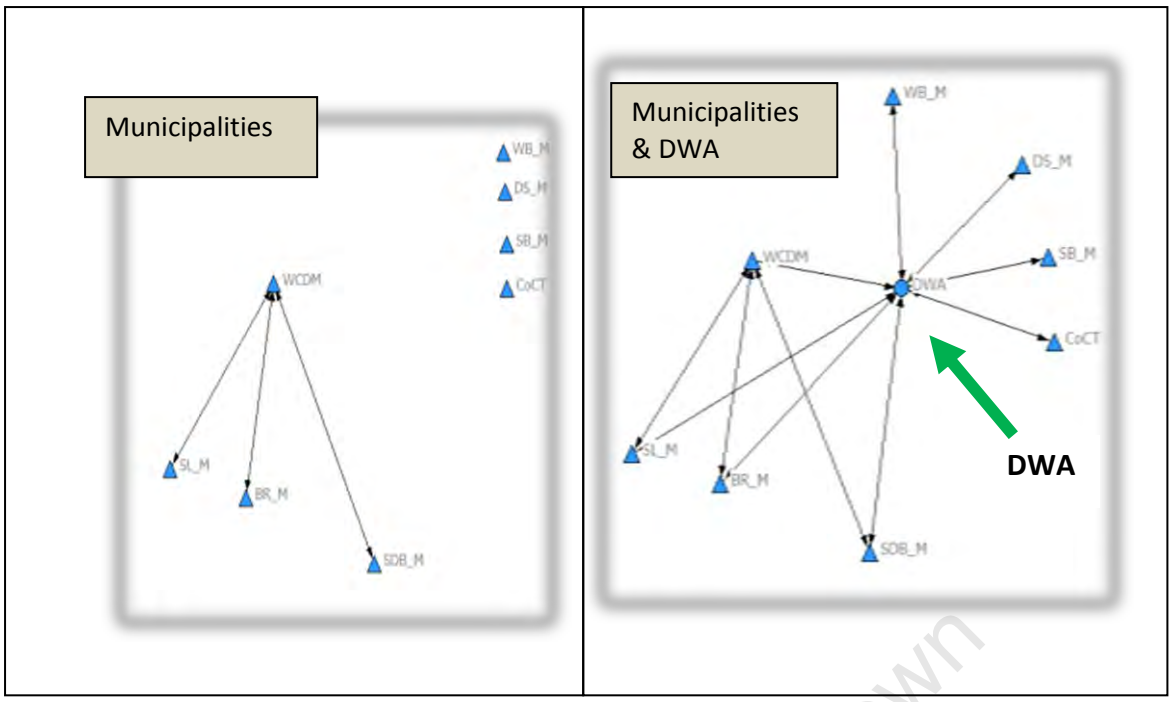

Figure 5-10: Ties among the municipalities

The left graph displays only the municipalities, in the right graph, the DWA is added to the group of actors.

The qualitative information from the survey reveals that the few relations that exists are formal and obligatory (i.e. the minimum required by the mandates). The municipalities interact with the DWA on a regular basis because they are required to report their water quality data monthly. The regular information exchange among the WCDM and the three local municipalities can be explained by the WCDM functioning as a WSP delivering bulk water to the three local municipalities. The collaborative relations go beyond these formal communication structures only in the case of two local municipalities (see Table 5-11). The Berg River Municipality works jointly with the WCDM in the Berg Management Estuary Forum. Stellenbosch Municipality and the DWA have partnered in a project as part of the national 'Adopt a River' program. While the former has been a highly productive relationship, the latter had, at the time of the study, not resulted in any effective collective action. Both collective action initiatives are discussed in detail in Chapter 6.

Table 5-11: Major information exchange and collaborative activities among the municipalities and the DWA

	Information exchange	Collaboration
Without DWA	• Only regular information exchange between WCDM and the three local municipalities based on contractual relation between WSAs and WSP	• Berg Municipality and WCDM through the Estuary forum
With DWA	• Obligatory information	• DWA and Stellenbosch

	exchange on water monitoring data • Several informal meetings between municipalities from upper catchment and DWA	established partnership on Adopt a River program

The marginalization of some of the municipalities in the network is exemplified by comparing the viewpoints that were articulated by the municipalities in the survey on the value of collaboration. The survey revealed two contrasting views among the municipalities. Municipalities from the lower catchment did not think that the collaboration in the Berg management network was of any benefit to them. They were of the opinion that their needs and interest were not taken into consideration in decision-making processes related to the Berg River. Concerns about bad taste in the drinking water or the water quality concerns of the local industry have not been directly acknowledged by the DWA or other decision makers in the catchment (Interview S-9). Feeling largely ignored and arguing that that their practices have little impact on the river (i.e. they do not contribute to the problem), these municipalities do not feel a strong need to collaborate. The representative from the WCDM, who is more involved in water management, had a slightly different view. He argued that better collaboration among municipalities from the upper and lower catchment was critical for ensuring the water security of the stakeholders in the lower catchment (Interview S-10). The municipalities from the upper catchment were of the opinion that collaboration (especially the informal engagement with the DWA and the Main IB) has been beneficial. One survey respondent argued that the engagement with the DWA has increased their access to governmental grants (Interview S-8). Furthermore, the pressure from the DWA (e.g., by issuing pre-directives) and the IBs (by threatening with legal actions) has enabled some of the municipal water service departments to put political pressure on higher level decision makers within their own organization (Interview S-8, S-7).

The representatives from the municipalities mentioned several internal and external barriers that prevent the establishment of sustainable collaborative relations among the municipalities and to other organizations in the catchment. There is a general perception among all municipalities that it is the responsibility of the DWA to manage the river and not that of the municipalities. This seems to reduce the willingness to engage more proactively in river management. A clear distinction between water service provision and water management (i.e. river management) was made. An expectation are the Drakenstein Municipality and WCDM which, given their internal expertise within their environmental departments, are taking a more holistic approach. This has been supported by the

quantitative analysis that these two municipalities are highly engaged in the catchment.[87] The SNA respondents from the municipalities also stated that, given the low support from senior municipal officers and the limited resources that are available to them, they barely can manage their day-to-day activities. They argue that under such conditions it becomes almost impossible to engage collaboratively with others from the catchment. Yet, the municipalities in the upper catchment acknowledged that closer collaboration with others can lead to more political visibility of the problem as well as increases in funding possibilities. Several of the municipal representatives further pointed out that it is not the absence of intergovernmental meetings but the quality and ad hoc manner of those meetings that inhibits systematic communication and collaboration. Many of those meetings turn out to be just "talk shows" in which problems are tabled but not followed by concrete and systematic plans of action (Interview S-11,S-12.

5.3.3.3. Conclusion on cohesion among key WMOs

Effective catchment-wide water management necessitates that in particular the core WMOs, i.e. those organizations with a specific mandate for the management of the catchment's water resources, are well connected. Unfortunately, the analysis shows that the interactions among the core WMOs operative in the Berg catchment is sparse. The limited interactions (in terms of quantity and content) are not enough to develop a functioning information exchange system and for aligning plans or actions. As a consequence, neither a common vision for the catchment nor a problem definition that indicates the interdependence of the organizations as well as their dependence on the river for their water security can be observed. Hence, important prerequisites for addressing the issue of degrading water quality jointly are missing. Furthermore, without close coordination and cooperation the core WMOs will continue fall short of carrying out key management activities effectively.

Yet, the investigation also shows that the group of IBs is highly competent and effective. This appears to be the result of the strong cohesion within the group of IBs, which is facilitated through a star-like network structure and trust relations. This cohesion is expressed through the high level of collective action and self-organization among the IBs. The way they have organized does not only ensure effective information exchange and coordination of collective action among them, but also provides the group of IBs with access to important external resources (e.g., knowledge) and decision-making processes.

The findings suggest that establishing collaboration relations within the group of municipalities (but also to other organizations) is significantly constrained by several factors. Among them are limited internal capacities (e.g., adequate staff and infrastructure for water service provision, expertise on

[87] Measured by the number of links the organizations have to other organizations in the network (see degree centrality in Table 5.8).

water resources management, inadequate monitoring systems), the differential dependency on the river (Table 5.9), and the lack of willingness to engage more actively in the management of the Berg River. Whereas the interaction among the IBs builds on strong trust relations, that of the municipalities are formal and obligatory relations (Table 5.10 and 5.11). Although the DWA has been identified as a central actor among the core WMOs, the findings suggests that the DWA has so far not been able to enhance the communication between the municipalities or the municipalities and the IBs.

5.3.4. Identifying strong ties and cohesive sub-groups

This section explores how organizations have organized themselves in the network to address the issue of degrading water quality. This is done through a cohesive sub-group analysis. Hence, instances of collective action are depicted by focusing on the relational data of the Berg management network without taking into consideration attribute data of the organizations.

Chapter 3 highlighted that cohesive sub-groups are sub-sets of actors that distinguish themselves from the rest of the network through their shared strong, mutual, direct ties (Wasserman and Faust, 1994). Since this study only considers reciprocal ties among the organizations, the criterion of mutuality (i.e. ties that are reciprocal) is not helpful. However, the valued network N(v) is a multiplex[88] network (i.e. two actors are connected through more than one type of relation) and allows the distinguishing of the tie strength among the actors (ranging from 0 to 2). The strongest ties can be found among those organizations that exchange information on a regular basis and collaborate with each other (i.e. all relations with a value of 2). To be able to only focus on the strongest ties, a new network was created in UCINET that only considers the ties with a value of two from the valued network N(v). In UCINET, the network N(v) was dichotomized at the cut of value of 2, meaning links with a strength less than two received a value of 0. The new network is called from here on the 'collective action' network.

5.3.4.1. Comparing the information network with the 'collective action' network

Before turning to the cohesive sub-group analysis, it is worthwhile to compare information exchange (information network) with the collaboration ('collective action' network) among the actors operative in the Berg catchment. Figure 5-11 shows that the two networks differ greatly in their shape. It appears that 11 organizations from the actor set do not collaborate with any other organization. They can be identified as isolated nodes on the upper left corner of the right graph. Among them are the metropolitan municipality of Cape Town and one local municipality from the

[88] The idea behind multiplexity is that when actor share more than one kind of relational tie they are more likely to have a strong relation and therefore are more likely to influence each other (Erickson, 1988).

lower Berg catchment. In addition, small groupings, one containing two organizations (of which one is another local municipality) and the other three organizations, are separated from the main component of the 'collective action' network. Table 5-11 shows that the density in the 'collective action' network (when considering all 54 actors) is reduced by more than 50% and based on the diameter and average distance that the organizations require more time and effort to reach each other. The lower centralization scores suggest that catchment-wide collaboration is not coordinated by one specific actor. Hence, in comparison to information exchange, collaboration is decentralized and concentrated among fewer actors.

Based on the qualitative understanding of the interaction in the Berg management network, it seems that the information exchange among most organizations is structured along formal relations. Collaboration, on the other hand, seems to capture so called 'choice' relations[89] or informal relations. This suggests that the 'collective action' network provides a good indication of where in the network capacities effective incentive structures and (or) trusting relations exit.

Another interesting observation can be made with regard to the two central actors that were previously identified in the Berg management network. The degree centrality measures (see Appendix 5.3) for the 'collective action' network show that the Main IB continues to be one of the most active and influential organizations but that the DWA's role is rather peripheral. This implies that the DWA is not highly engaged in collaborative activities. Given its rather peripheral position, it also seems to be unlikely that the DWA would be able to coordinate the collaborative efforts in the Berg management network.

[89] Choice relations are defined here as relations that are pursued by the organizations because the organizations have confidence in the other actors competencies (capacities and willingness to fulfill their obligations). These relationscan be formal but they are not mandatory, i.e. actors have a choice to pursue this relationship.

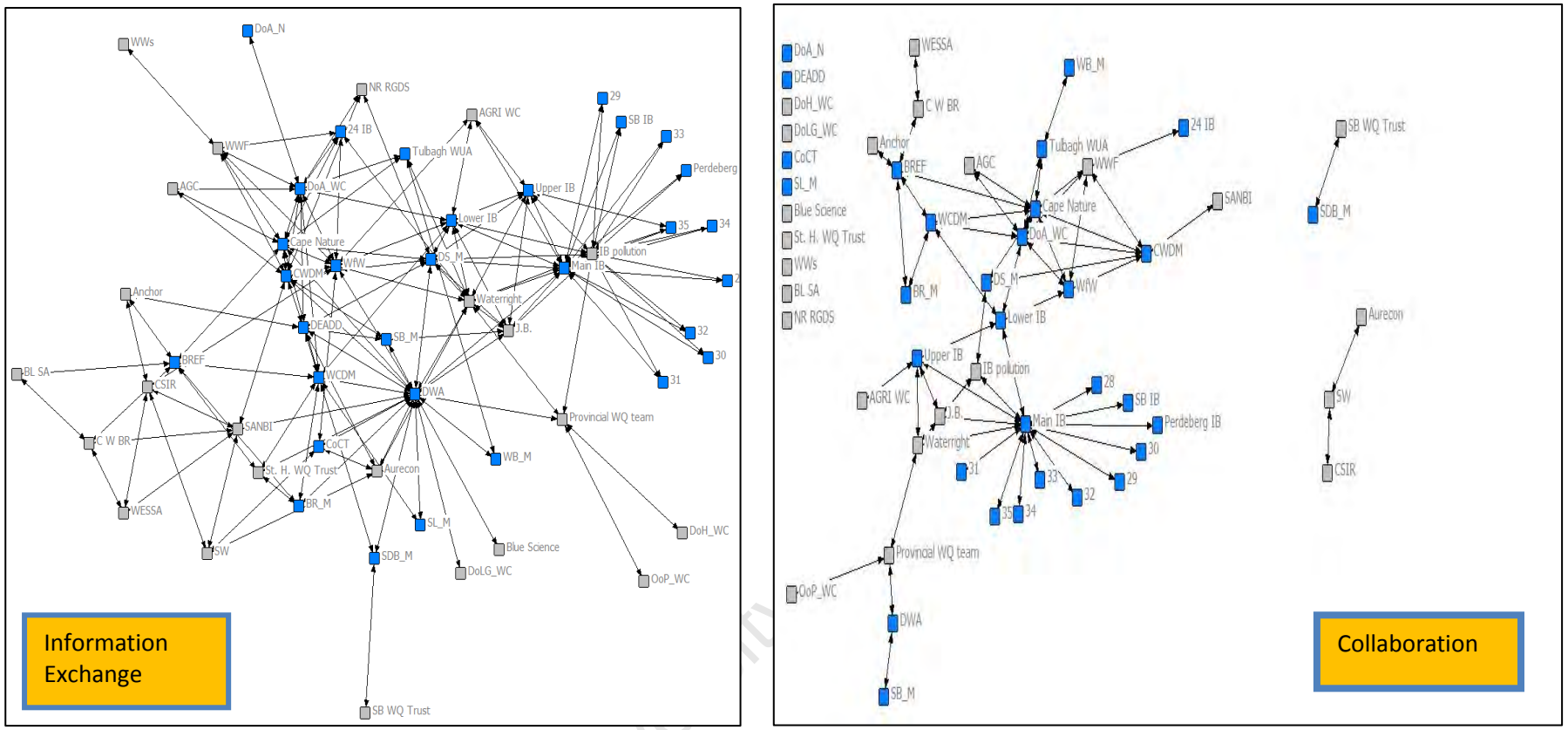

Figure 5-11: Comparing information exchange (left graph) and collaboration (right graph) in the Berg management network

Blue nodes= mandated actors, grey nodes =non-mandated actors

Table 5-12: Comparing information exchange and collaboration in the Berg management network

Network	Size	Density (%)	Degree centralization (%)	Betweenness centralization	Av. degree	diameter	Av. distance	components
Information	54	10.1	30.7	35.96	5.33	5	2.60	1
'Collective action'	54	4.3	24.96	23.74	2.26	9	3.36	14

5.3.4.2. Cohesive sub-group analysis: identifying collaborative clusters

The Girvan-Newman algorithm (Girvan and Newman, 2002) function in UCINET and NETDRAW was used for the sub-group analysis of the 'collective action' network. The specific aim was to identify self-organized collaborative efforts among the diverse set of organizations that comprises the Berg management network[90]. The algorithm divided the network into six cohesive grouping. The partition choice was based on the highest score of the Q value[91] and confirmed by the qualitative understanding of the network.

Figure 5-12 shows that the large main component of the 'collective action' network containing 38 organizations was further divided into 4 distinguishable collaborative clusters visualized through different colors. In addition, two smaller components that are not connected to each other or to the main component were also identified as isolated clusters by the partition. The symbols representing the nodes indicate that the clusters are quite diverse in terms of the type of organizations.

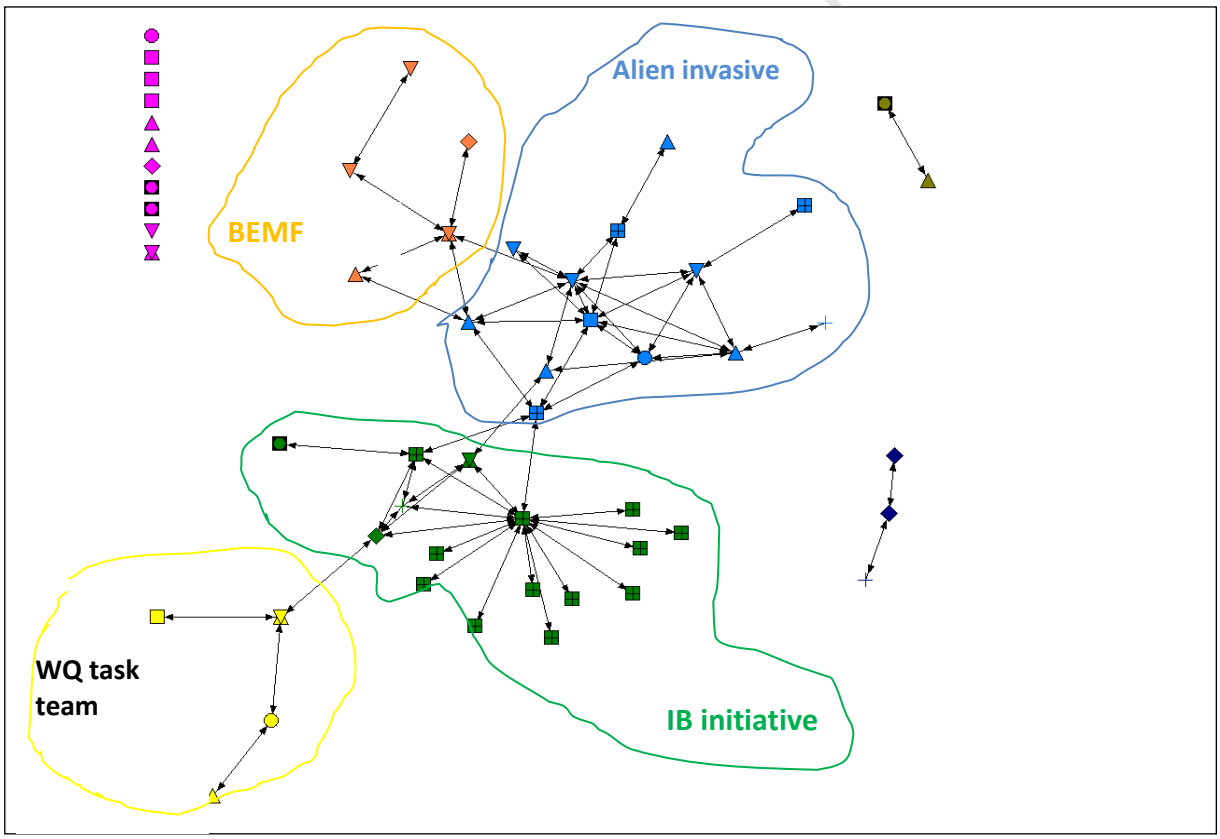

Figure: 5-12: The 'collective action' network partitioned into six cohesive sub-groups
The sub-groups are distinguished by the different colors of the nodes.

[90] See Chapter 3 for a detailed explanation of the algorithm.

[91] The Q value is a score that describes how good each partition is in terms of dividing the network into specific groupings. It does so by comparing the number of internal links in the sub-groups with how many one would expect if these links were distributed randomly (Borgatti et al., 2013; Newman, 2006).

A first examination of the activities of those groupings revealed that the four collaborative clusters represent the greatest efforts to address the issue of degrading water quality in the catchment. They include:

- the self-organizing efforts of the IBs (The IB Initiative);
- an assortment of organizations that are trying to tackle the issue of alien invasive vegetation (The alien invasive clearing cluster);
- another group collaborating through an estuary forum which has been established to protect and manage the Berg River estuary (The Berg Estuary Management Forum);
- the formal response of the DWA to the issue of water quality (i.e. the establishment of an intergovernmental platform to coordinate efforts related to issue of water quality among relevant government organizations) (The Water Quality task team); and
- 2 smaller collaborative efforts. [92]

For the rest of the discussion, only the 4 clusters from the main component are considered and the two smaller clusters are ignored as their current contribution to the Berg management network remains minimal.

The IB Initiative

Based on the findings of the interactions among the core WMOs, it is not surprising that the group of IBs organized around the Main IB form a cohesive sub-group. It supports the argument from the previous section that this group is characterized by a high level of cohesion. The close and iterative cooperation of the IBs with different experts has become institutionalized in form of a pollution committee. The partition incorporated members of the pollution committee into the cohesive sub-group of the IBs. The group of 16 organizations is visualized as the green cluster in the graph of Figure 5-12.

The alien invasive clearing cluster

The blue cluster is a heterogeneous group which includes NGOs, government departments, but also several IBs. While the cluster encompasses different initiatives, all organizations are engaged in the

[92] In Figure 5-12, the purple cluster contains a group of consultancies that have been working closely together to generate ecological knowledge on the Berg River. The lime green cluster includes a local municipality and a Trust organized by the local industry (primary fishing sector): The trust coordinates a water quality monitoring program to monitor the discharge of representatives from local industry ((Interview S-13). The geographic focus of the monitoring program is the coastal area surrounding the Berg River Estuary.

collaborative activities with the objective to reduce the problem of alien invasive vegetation. Alien vegetation is a serious issue in the catchment which directly and indirectly contributes to the degrading water quality of the Berg River.

The Berg Estuary Management Forum (BEMF)

The orange cluster is a forum that brings together government organizations, NGOs, as well as representatives from local stakeholder groups with the aim to manage the Berg River Estuary jointly.

The Water Quality task team (WQ task team)

The yellow cluster is made up of a group of government agencies that are involved in an intergovernmental platform coordinated by the DWA to officially address the water quality issues in the Berg. Important to note is that the WQ task team formally comprises several other organizations of which some are part of the Berg management network. However, these actors were of the opinion that the WQ task team is not an effective platform for information exchange and collaboration. Consequently, these organizations did not indicate in the SNA survey that they have regular interactions with the platform and its members. Hence, they do not feature as part of this cohesive sub-group. Among those organizations are several municipalities as well as the IBs.[93] (For a further discussion on the WQ task team the reader is referred to chapter 6).

The four identified collaborative clusters differ in several aspects. Whereas the IB initiative, the BEMF and the WQ task team are singular initiatives, the alien invasive clearing group contains several initiatives. Furthermore, the initiatives of the WQ task team and IB initiative are specific responses to degrading water quality. The BEMF and the alien clearing cluster have been established for broader purposes, i.e. they are not confined to the issue of water quality, but are concerned with the health of the river system in a broader sense. However, all of the groups address water quality as a specific issue. Sharing knowledge among the collaborative clusters and coordinating actions could be highly beneficial for catchment-wide management of the river. To further assess the cohesion among, and tie distribution within, the collaborative clusters, the ratio of intra -group ties and ties across the clusters (cross-boundary ties) was examined. Furthermore, centralization and average degree[94] within each sub-group was measured. All measures were done on a new matrix (38x38) which was created in UCINET and only included the main component.

[93]The WQ task team rarely met in the period from 2010 to 2012. The organizations therefore argued that the interaction within the WQ task team has been too sporadic to foster the regular exchange of information and collaborative relations (Interview S-15, S-11, S-1).

[94] Average degree refers to the average number of ties a actor has to others in the specified group.

Table 5-13: Basic measures collaborative clusters

Sub-group	Size	# of ties	Avg. Degree	Density	Centralization
Cluster green (IB imitative)	16	40	2.5	0.167	87.62
Cluster black (alien clearing)	13	48	3.7	0.308	42.42%
Cluster orange (BEMF)	5	8	1.6	0.4	58.33%
Cluster yellow (WQ Task team)	4	6	11.5	0.5	33.3%

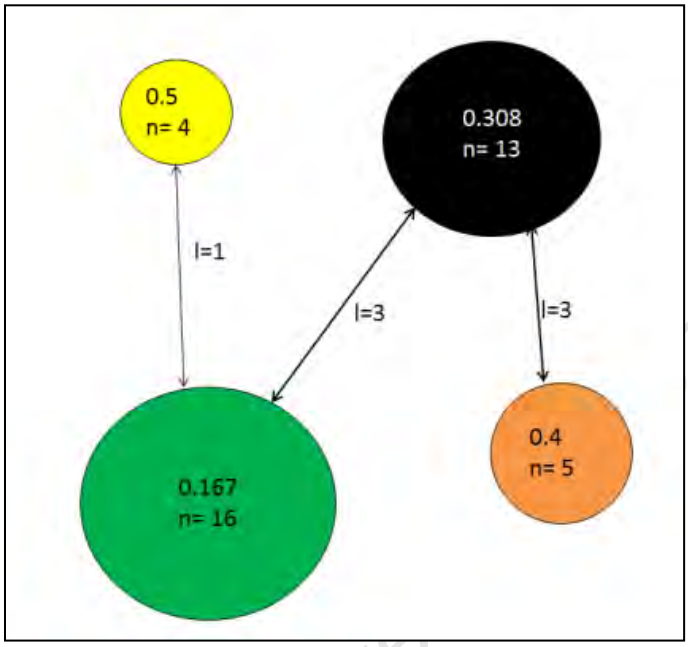

Figure 5-13: Level of cross boundary interactions

Table 5-13 shows the density and centralization scores within the groups. While the different group sizes made it impossible to make a comparison of the density scores, it is interesting to note the high centralization scores of IB initiative and theBEMF. These suggest the presents of a coordinating actor in both initiatives. For the IB initiative that means that despite the inclusion of the experts in the group, the central role of the Main IB remains intact. It has been previously mentioned that the alien clearing initiative is composed of several smaller initiatives. Nevertheless, most organizations appear to be well connected to each other (high density and average degree, moderate centralization) and no structural distinction could be observed between the initiatives. Comparing the ratio of intra-group ties and the ties across the groupings (Figure 5.13), it appears that the interaction among the 4 groups is quite limited. However, the SES literature has in particular emphasized the importance of cross-boundary interaction among sub-groups for creating a holistic understanding of SESs such as the catchment and for allowing effective management of such complex system (e.g., Berkes and

Folke, 1998; Sandstöm, 2008). Figure 5.13 provides a simple visualization of the cross-boundary interactions four collaborative clusters. There it becomes evident that the existing linkages are too limited for coordinating catchment-wide collective action.

5.3.4.3. Identifying organizations that link the collaborative clusters

While the cross-boundary linkages that connect the four self-organized groupings are sparse, it might still be important to find out what organizations have facilitated these linkages. To identify organizations that bridge the collaborative clusters, the 'weighted' G-F brokerage method was used in UCINET. This method and the five possible brokerage roles that an actor can assume have been described in Chapter 3.[95] Of importance for the discussion below is to know that the cross-boundary brokerage score for each organization has been calculated by adding the scores for the Gatekeeper, Liaison and Consultant role (See Chapter 3 for a explanation of the terms). Organizations that have a high score for the Coordinator role are organizations that link many organizations within their own sub-group. Table 5-14 lists key bridging organizations identified with the G-F brokerage function.

[95]Since the 'collective action' network is solely comprised of symmetric relations, the gatekeeper role and the representative role are the same. Gatekeeper/ representative = actor acts as contact between members of his group and another group. Liaison = actor links two organizations that are members of different groups. Coordinator= links actors of its own group. Consultant = links two actors that belong to the same group but to which the actor does not belong.

Table 5-14: Key bridging organizations connecting the four self-organized collective action initiatives For comparison purposes the intra-group brokerage roles are listed on the right.

Cross-boundary brokerage		
Collective action initiative	organization	Brokerage score
IB initiative	Main IB	12
Alien(BEMF)	CapeNature	6,5
Alien (IB)	Lower IB	6
BEMF	BEMF	4,5
Alien (BEMF)	WCDM	4
IB	Wright	4
WQ task team	IB pollution	3
Alien	DS_M	2
IB initiative	Upper IB	2
WQ task team	WQ task team	2
WQ task team	DWA	0

Within-group brokerage		
Collective action initiative	Organization	Brokerage score
IB initiative	Main IB	170,7
Alien (Estuary)	CapeNature	20,7
Alien	DoA_wc	18,3
Alien	CWDM	13
Alien	WWF	8
BEMF	BEMF	6
IB initiative	Upper IB	6
Alien	Tulbagh WUA	4
Alien	WfW	2,7
WQ	Provincial WQ team	2
WQ	DWA	2

The organization with the highest cross-boundary broker score is the Main IB followed by CapeNature, the Lower Berg IB, BEMF, the WCDM, and Wateright consultancy. The brokerage analysis revealed that cross-boundary linkages between the clusters were only realized in situations where the broker connects his/her group to another group (the gatekeeper/ representative role).[96] However, catchment-wide collective action would benefit from a network that does not just have brokers (gatekeeper) that do connect their group with other groups, but also includes brokers (liaison) that facilitate the collaboration between other groups.

To sum up, the cohesive sub-group analysis was able to demonstrate that quite a large number of organizations exist that have organized into collaborative groupings with the aim to jointly address major management issues in the catchment. In comparison to information exchange, it appears that the organizations are more selective about whom they collaborate with. Collaborative relations are primarily choice relations that signal a certain level of trust in each other's competencies. Most clusters are characterized by a diverse membership. That is, collaborative relation can be found among state and non-state actors as well as mandated and non-mandated actors. This suggests that the need for joint action and the pooling of resources is acknowledged by many of those organizations. However, the investigation into the cross-boundary linkages also revealed that the interactions across the clusters are not sufficient to achieve catchment-wide collective action. While

[96]None of the 38 organizations connected two organizations from two other initiatives (the liaison role). Nor did any organization link two organizations that are part of the same initiative but to which the broker has no affiliation (consultant role).

the Main IB continues to be a highly influential actor, it does not use its influence to enhance the overall collaboration and self-organization of the Berg management network. The brokerage analysis identified several other actors that bridge the collaborative clusters. However, the qualitative data revealed that their influence on the functioning of the entire network remains limited, as they lack the necessary formal authority and access to catchment-wide information. Consequently, the cross-boundary linkages do little to increase cohesion in the network.

5.4. Heterogeneity: Level of cross-boundary interaction

The participation of a diverse group of organizations that have different relations to the Berg River and which possess various resources can enhance the ability to recognize and deal with changes in the SES at the appropriate scale as well as to maintain important management functions (Folke et al., 2005). The first part of the chapter showed that the Berg management network is composed of a diverse actor network rich in resources, skills, and expertise. In theory such a network creates many opportunities for adaptive water management in terms of the pooling of resources, compensating for limited capacities of individual actors, or for creating innovative solutions. Yet, if organizations with a wide range of interests, needs, and capacities are involved, this also means that it is often difficult to establish a common vision and to overcome conflicts of interest. A substantial amount of time and effort is required to establish trust or at least functioning relationships. In other words, in order to harness the heterogeneity of a group of organizations, a certain degree of cooperation between the organizations must be established. The embeddedness of ecological knowledge, the integration of all relevant actors, and the existence of important cross-boundary linkages are all facilitative factors that can help to enhance the willingness to cooperate (Armitage et al., 2009).

This section uses a variety of network measures to assess to what extent the heterogeneity of the Berg management network is utilized. First a core-periphery analysis is employed to examine the participation of major users and stakeholders highly dependent on the Berg River. Of interest here is to establish whether these actors are well embedded in the network or marginalized. It is assumed that the better an organization is connected in a network the more the organization can contribute knowledge, resources, and perspective (including interests and needs). This is followed by an assessment of the embeddedness of ecological knowledge in the network. Organizations that have an adequate access to credible ecological knowledge tend to form an informed understanding of the SES, find common interest, and establish a shared vision for the management of the SES (Biggs et al., 2012). Finally, cross-boundary linkages in the network are examined with help of the E-I Index in UCINET. The Index enables the researcher to calculate the proportion of ties that connect organizations of different kinds. The focus is on linkages between sectors and interactions between the three ideal governance modes.

5.4.1. The integration of major water users and dependent stakeholders

It is assumed in this study that a precondition for effective adaptive water management in the Berg catchment is that all major water users are part of the network and that those highly dependent on the water resources of the Berg River are either well embedded in the actor network or are well connected to central organizations in the network. Major water users are defined as stakeholders that have a significant impact on the river through their activities. These activities include, among other things, abstraction, discharge, or altering the watercourse. Equally important is the identification of those stakeholder groups that may not be the largest users but who have a high dependency on the Berg River with regard to their water security. Water may be used for productive purposes, for drinking water or for the maintenance of ecological services or functions.

While major water users in the catchment were presented in the beginning of this chapter, a more detailed list of users (based on the SNA survey and reports) is provided in Table 5-15. In addition to listing major users, the table further specifies stakeholder groups who depend largely on the water resources of the Berg River for their water security (i.e. through water abstraction). The table shows that while stakeholder groups from the upper catchment (Drakenstein, Stellenbosch, and Witzenberg Municipality) have the highest impact on the river through their wastewater discharge, it is stakeholder groups in the lower catchment that have the highest dependency on the river system for their water security.[97]

[97] The three local municipalities (Swartland, Bergriver, and Saldanha Bay Municipality) are fully dependent on the Berg for their drinking water supply (Interview S-11). The steel and metal industry, an important economic sector in the Saldanha Bay Municipality, requires good water quality for its operations (Interview S-9). The fishing sector in the Bergriver Municipality and the industry of the Saldanha Bay Municipality also need good water quality. The estuary and its bird areas are key contributors to the eco-friendly tourism sector of the municipality Interview S-14).

Table 5-15: List of major users their impacts on the River system and stakeholder groups highly dependent on water sources from the Berg River

Major user	Impact	Dependent stakeholders including ecosystems	Dependency
City of Cape Town	Water abstraction	Bergriver Municipality	Drinking water supply, eco-friendly Tourism, Fisheries
IBs	Water abstraction	Swartland Municipality	Drinking water supply, Steel and Metal industry, Fish factories
Drakenstein Municipality	Discharge	Saldanha Bay Municipality	Drinking water , Industry, Steel and Metal industry, Fish factories
Stellenbosch Municipality	Discharge	BEMF(representing needs of the estuary)	Estuary ecosystems and breeding areas for fish species
Witzenberg Municipality	Discharge (Tributary)		

5.4.2. Core-periphery analysis

For the purpose of this thesis, a core–periphery analysis (Section 3.1.4) was undertaken to identify those organizations in the Berg management network that, because of their peripheral positions in the network, are rather marginalized.[98] The analysis was done on the valued Network N(v) to detect marginalized organizations in the Berg River catchment. The UCINET core-periphery continuous function placed 13 organizations into the core and 41 organizations into the periphery.

[98] A similar approach for identifying marginal actors was used by Vance-Boreland and Holley (2011).

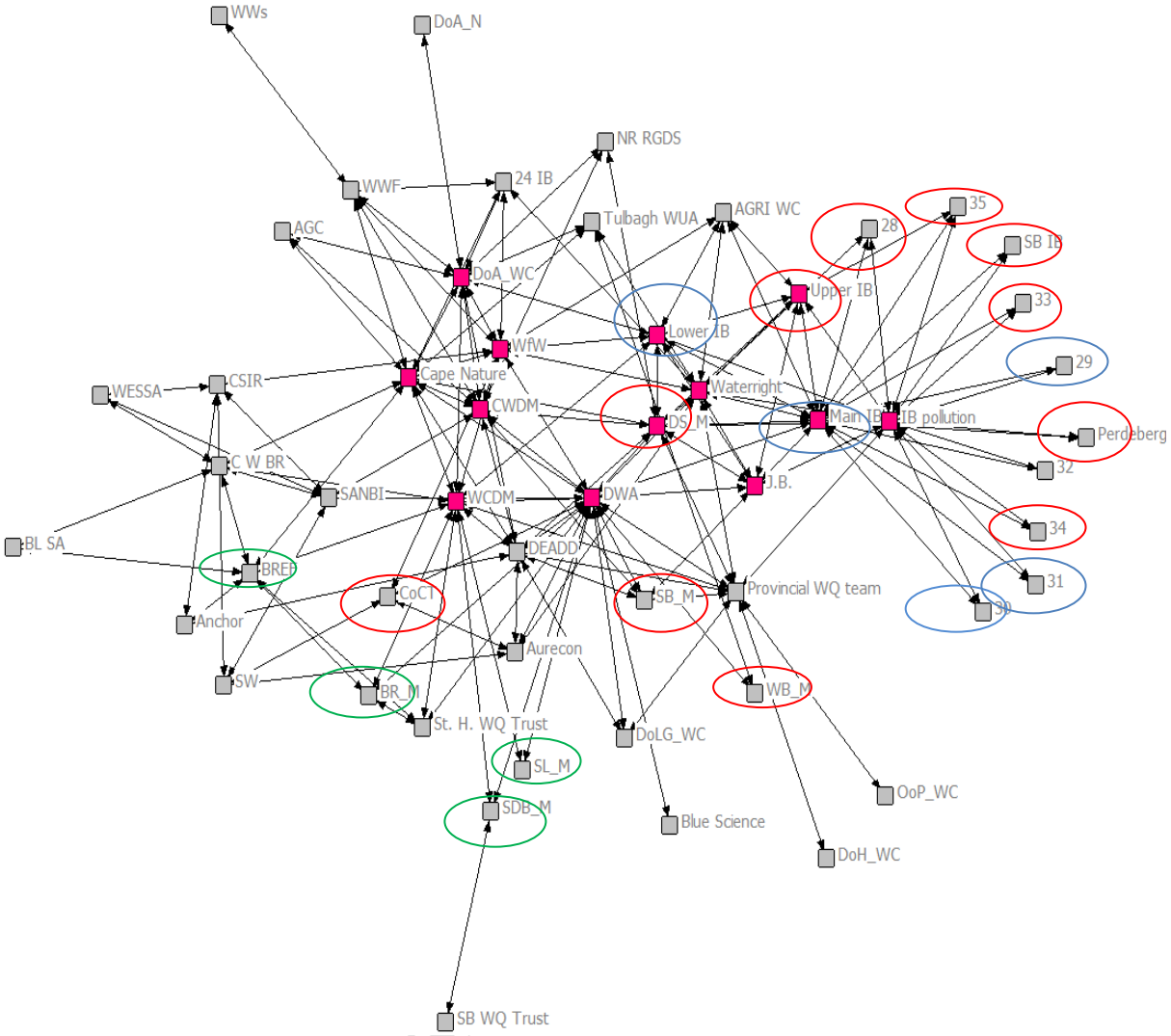

Figure 5-14**:** Core-Periphery structure of the valued network N (v)

Pink nodes = Core actors (total 13), grey nodes= Peripheral nodes (total 41), Red circle=major user, blue circle= major user and dependent stakeholder, green circle =dependent stakeholder

Figure 5-14 demonstrates that many of the IBs occupy peripheral positions in the network. However, the previous analyses demonstrated that their interests and needs are well represented through the Main IB and other supporting organizations such the IB pollution committee. The metropolitan municipality of Cape Town, a large user of the river, is on the other hand not well embedded in the network. This confirms the qualitative understanding that the City of Cape Town has so far taken a rather passive role in addressing the issue of degrading water quality in the Berg management network. Being a well-resourced and influential actor in the Western Cape Province, the City of Cape Town can use higher level decision-making platforms to ensure that its interests are protected (e.g., the Western Cape reconciliation strategy steering committee). Of the three local municipalities from the upper catchment that were identified as having a significant impact on the river in terms of discharge and related pollution problems, only one can be found among the core organizations. The other two take peripheral positions in the network. That these users are not well integrated in the

management network has negative consequences in several ways. They currently lack a holistic understanding of the catchment system and are rather oblivious as to how their current and future actions affect the Berg River and other users. Furthermore, not being well connected to other organizations may indeed hamper their own problem-solving capacities as they can't easily turn for advice or resources to other organizations involved in the management of the Berg River. Without being more integrated in the decision-making processes concerning the Berg River, their motivations for collaborating with others on issues of degrading water quality and their awareness of and compliance to established rules and shared responsibilities will remain low.

Table 5-15 has pointed out that stakeholder groups from the lower Berg catchment, in particular, are highly depend on the Berg River for their water security. However, the core-periphery analysis shows that organizations representing these stakeholder groups are primarily located in the periphery of the network (e.g., local municipalities of the lower catchment as well as Estuary forum which represent the interests and needs of the estuary). While all of the organizations are directly connected to the DWA, this is currently not particularly beneficial since the DWA does not have the capacity to advocate their interests. Also of concern is that other stakeholder groups that are dependent on the river system are not part of the management network at all. Among them are farm workers, emerging farmers, and residents of informal settlements. One reason as to why they do not partake in the network is that they often lack organizational structures that represent needs and interests of individuals belonging to the stakeholder group. This is especially the case on questions that relate to their water security. Because of this it was difficult to predict the level of their dependency (or impact) on the Berg River within the scope of this study. Nonetheless, their lack of visibility in the Berg management in the network is worrisome.

That the 'dependent' stakeholder groups mentioned above only have marginal positions in the network reduces the chances that their interests and needs are considered in current and future decision-making processes concerning the management of the Berg catchment. However, they are also some of the most vulnerable users. Unlike other users, they are less likely to have alternative options available for their water security.[99] To illustrate the point, it might be useful to provide an example from the Saldanha Bay Municipality. The municipality receives most of its water from the Berg River. Some industries and residents frequently have complained about the quality of the water (Interview S-17). They are particular concerned about the taste (residents) and issues of salinity and conductivity (industries) (Interview S-9). Yet, so far their concerns have been ignored. The Saldanha Bay Municipality has ambitious development plans for the near future, e.g., the establishment of an

[99]For example, while IBs from the upper catchment depend on the river system they also use dams or boreholes for their water supply.

Industrial Development Zone which is estimated to create up to 11,975 total jobs.[100] While other water sources such as the construction of desalination systems are being considered, demands on water from the Berg River are likely to substantially increase. If the development plans and water needs of the region are not well integrated and synchronized with the current and future management strategies for the Berg River, then the water security of the region will be at even greater risk.

To summarize the findings from the core-periphery analysis: the results show that some of the organizations that have the biggest impacts on the river and those that are highly dependent on the river for their water security are not well integrated into the Berg management network. This has reduced the possibility to develop a holistic understanding of the catchment certain needs, impacts, and interests remain ignored. If major users, and in particular major polluters, are not more involved in information sharing and collective action initiatives of the network then their compliance, motivation and capacities to contribute to the management of the Berg catchment will remain poor.

5.4.3. Embeddedness of ecological knowledge

This section explores the extent to which ecological knowledge is embedded in the network and contributes to its heterogeneity. This is done by examining which organizations have direct access to ecological knowledge sources. Ecological knowledge sources are referred to here as organizations from the network that either produce scientific reports or generate experiential ecological knowledge as a result of their specific water resource management functions. The focus on the generation and distribution of ecological knowledge among the organizations involved in the management of the Berg River is based on the assumption that a better understanding of the ecological functioning of the SES is vital for developing and applying sustainable management practices and strategies (e.g., Biggs et al., 2012).

The Berg River is a highly modified and complex SES. It is especially altered through the technical infrastructure of the Western Cape water supply system of which the Berg River is an integral part. This has also led to complex relationships between the users (including managers) and the Berg River. Many users (including managers) do not directly interact with the river. Consequently, the awareness of how the river contributes to their water security or socio-economic well-being is rather limited. Others that directly interact with the river may not depend on its water sources. Under such circumstances, it can simply not be expected that many users possess adequate local ecological knowledge. In order to enable users and managers to make informed decisions leading to sustainable

[100] Press release Engineering News: http://www.engineeringnews.co.za/article/zuma-to-launch-saldanha-bay-idz-2013-10-09

practices, the distribution of scientific and experiential knowledge on the river, its ecological functioning as well as its importance to the overall prosperity of the region is critical.

A significant amount of knowledge on the Berg River in form of scientific reports were generated in the period of 2005-2009 in the context of the Berg River Dam project. (e.g., the baseline studies of Anchor Environment). Simultaneously, ecological knowledge on the Berg catchment was communicated to many stakeholder groups in the preparation for the establishment of the Berg CMA (Interview S-14). However, the generation and in particular the distribution of ecological knowledge has since mostly stagnated (Interview S-14, S-15).[101]

To assess the integration of ecological knowledge (scientific and experiential) in the network, first the knowledge sources in the network were identified. Scientific reports that provided ecological knowledge on the Berg River catchment were scanned in order to find out which organizations of the network function as scientific ecological knowledge sources and have made contributions to these reports. Additionally, based on the information that the respondents provided as part of the SNA survey, organizations were assessed as sources of experiential ecological knowledge based on their work in the catchment (monitoring of ecological processes, conservation and rehabilitation practices etc.).[102] Then, the integration of the knowledge sources in the network was examined in UCINET.

Table 5-16: Ecological knowledge sources in the Berg management network and their linkages to other organizations (non-ecological sources)

Ties among sources refers to the information sharing among ecological knowledge sources. No distinction was made between experimental and scientific knowledge

Scientific ecological knowledge			**Experiential ecological knowledge**		
ID	# of ties among sources	# of ties to non-ecol. sources	ID	# of ties among sources	# of ties to non-ecol. sources
DWA [G]	4	17	CSIR [R]	4	1
WfW [G]	5	7	SANBI [R]	3	3
DoA_wc [G]	3	9	J.B. [C]	1	7
CapeNature [G]/ [N]	4	9	Anchor [C]	1	2
WWF [N]	3	3	SW[C]	2	2

[C]= consultancy, [G] = government organization, [R]= research institute, [N] =NGO

Of the 54 organizations that comprise the Berg management network, 10 organizations were identified as ecological knowledge sources. Of those 10 sources, five are scientific knowledge generators and five are experiential knowledge generators. Table 5-17 provides an overview of the

[101] While smaller research projects and reports continued to be produced, they were often too project oriented and did not necessary feed into management strategies.

[102] While some of them are also producers of scientific knowledge, their role in this respect is rather limited in comparison to their experiential knowledge

identified knowledge sources and also lists how many ties they have to organizations that don't generate ecological knowledge on their own (non-ecological sources). The table shows that the main scientific ecological knowledge sources are consultancies and the two research institutions. Based on the interview responses and reports that are available on the catchment, it appears that the consultancies play a greater role in providing input into the management of the river than the two research institutions. Yet, the knowledge production by consultancies is often too fragmented and project oriented to create a holistic understanding of the ecological status of the river. The DWA, which in the past has been an important scientific and ecological knowledge source has, like many other government agencies, lost a lot of its technical expertise and therefore tends to depend on the expertise of consultancies for the development of its scientific reports (Interview S-15). Sources of experiential ecological knowledge in the network are primarily WfW and related local alien clearing teams that are part of the public works programs, CapeNature, WWF, Department of Agriculture, Western Cape and the DWA.

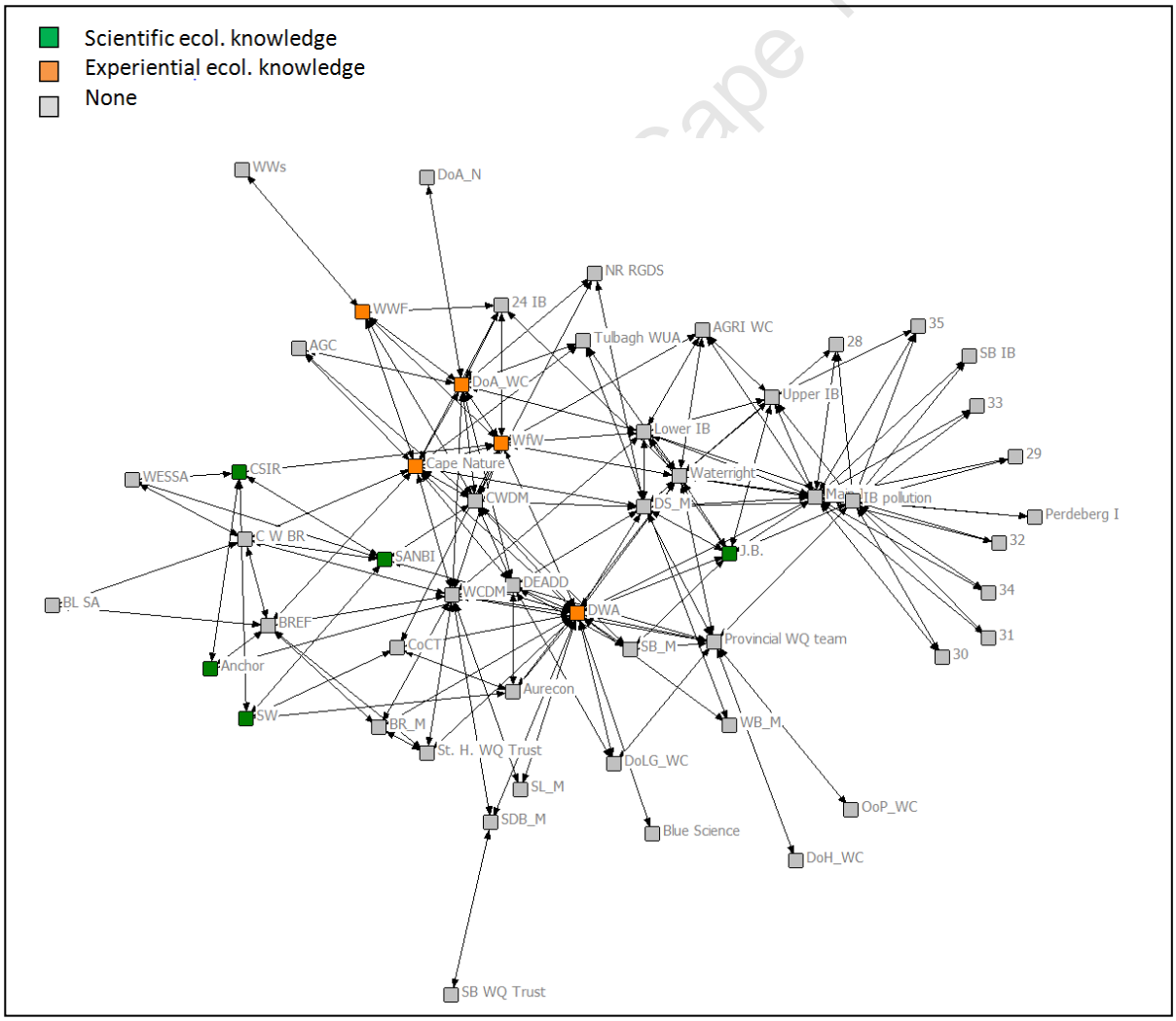

Figure 5-15: Organizations that produce ecological knowledge and their embeddedness in the Network N

The Figures 5-15, 5-16, and 5-17 indicate that the sources of scientific ecological knowledge are not well integrated in the actor network nor are they well connected to the core WMOs (especially not to local municipalities and IBs/WUAs). Based on the number of ties listed in Table 5-17 and the graph in Figure 5-17, it appears that organizations that generate a lot of experiential ecological knowledge are more engaged in the network then those generating scientific ecological knowledge. However, the interviews and the workshops suggest that the generated experiential knowledge is often not easily accessible to other organizations, nor is it proactively transmitted or shared by its producers. Yet, it is particularly this type of knowledge which is of great value for understanding interacting processes and trends in the catchment.

Table 5-17: Core WMOs with access to two or more knowledge sources (other than the DWA)

# of sources (w/o DWA)	Core WMOs
5	CWDM
4	24 IB
3	WCDM; Lower IB, DEA&DP_wc
2	Tulbagh WUA, BEMF, CWBR, Wright, DS-M

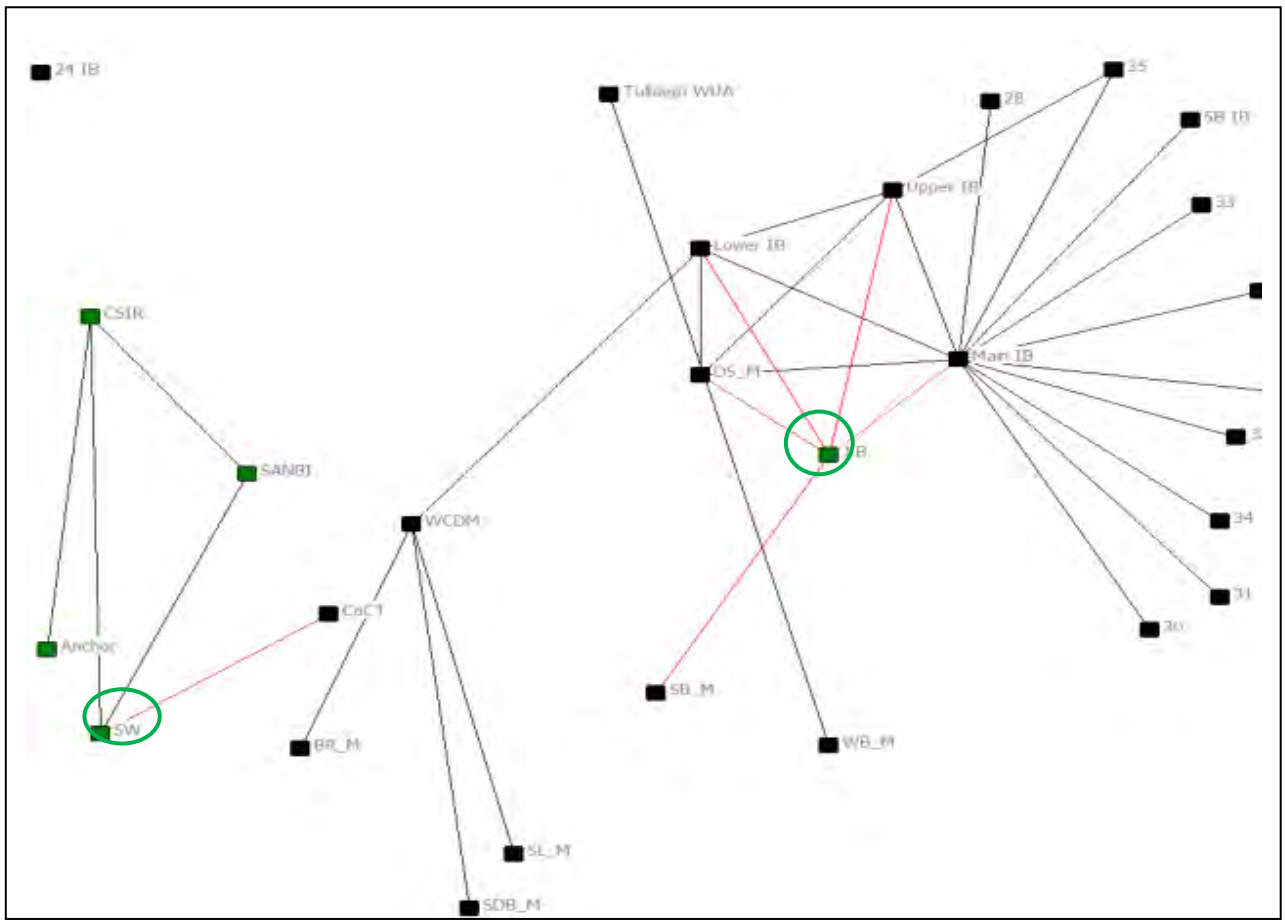

Figure 5-16: Linkages between scientific ecological knowledge sources (dark green cirlce) and core WMOs (black), Red lines represent the ties between knowledge sources and WMOs

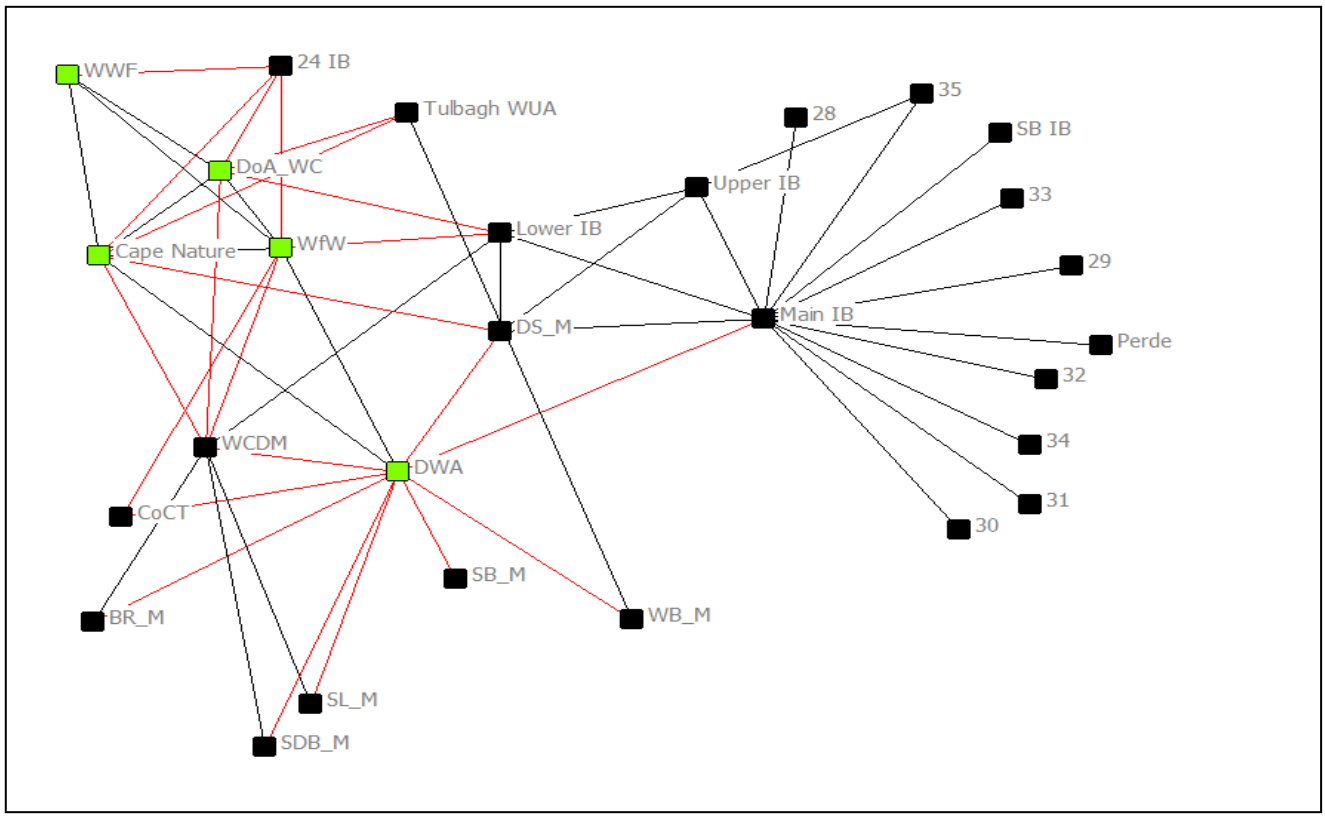

Figure 5-17: Linkages between experimental ecological knowledge sources (light green) and core WMOs (black), Red lines represent the ties between knowledge sources and WMOs

With most municipalities as well as other stakeholder groups possessing limited internal expertise on riparian ecology and river management the limited linkages to ecological knowledge producers are problematic.[103] Given that the DWA is currently not a reliable ecological knowledge source (because of inadequate number of technical staff and a poor communication system) the embeddedness of ecological knowledge is probably even poorer than depicted by the analysis. Of the 24 core WMOs 14 organizations have no direct access to an ecological knowledge source other than the DWA. Many of the interviewed organizations stated that they do not know to which organization to turn for ecological advice concerning the Berg River. Even when they know which organizations (e.g., DEA&DP and CapeNature) have expertise on a specific topic, they tend to fail to locate the right contact person (Interview S-7). The overall impression was that little is done by government agencies and NGOs to proactively support municipalities and IBs/WUAs in their decision making. The DWA and CapeNature who, based on their mandates, should support other water management organizations in ecological matters, are limited in their internal capacity to provide the necessary support (e.g., CapeNature has only three aquatic scientists which have to cover the entire Western Cape province and the DWA staff responsible for resource protection also need to assist the Eastern Cape province).

The only local WMOs that seem to currently benefit from access to scientific ecological knowledge are the IBs organized around the Main IB. Having interaction with one of the experts on ecological knowledge through the IB pollution committee, they are able to utilize this knowledge (primarily micro-biological) to advance their interests and to increase the legitimacy of their demands. The investigation into the generation and distribution of ecological knowledge in the network also revealed that those municipalities that have internal ecological expertise (Drakenstein Municipality and WCDM) have also access to multiple ecological knowledge sources (see Table 5-18). Hence, they reach out to other experts for support or find ways to highlight organizational mandates that are in line with sustainable resource management (Interviews S-3, S-10). Table 5-18 also reveals that it is actually the 24 River IBs and the WUA that are among those with access to multiple ecological knowledge sources. This stands in strong contrast to most other IBs who only have indirect access to ecological knowledge through the Main IB (the exception again is the Lower IB which, as mentioned previously, long acted independently of the Main IB and its other members.

Another observation that was made during some of the workshops the researcher attended, and which was further supported by the SNA analysis (e.g., the low levels of interaction between scientific and ecological knowledge sources), is that besides the need to enhance the linkages

[103] Of the total 60 ties that the ecological knowledge sources (n=10) have to other organizations (n =44), 30% are from the DWA only.

between WMOs and ecological knowledge sources, it is also critical to nurture the interactions among the ecological knowledge sources. Especially those working on similar issues, e.g., alien clearing or river rehabilitation tend to not benefit from each other's knowledge and experiences. Furthermore, the SNA identified other potential ecological knowledge sources that are part of the network but which currently make little contribution to knowledge generation. Among them are WESSA, DEA&DP, AGC, CWBR and the BEMF. While some are marginalized in the network (BEMF, AGC), others currently do not generate a lot of knowledge relating to the Berg River (DEA&DP, WESSA).

The observation that ecological knowledge is not well integrated in the network is further supported by findings of the fieldwork. The consequences of the inadequate generation and distribution of ecological knowledge became most visible in the ambiguity and presumptions articulated by many interviewees on the status of the river system. While almost all SNA respondents agreed that the degradation of the water quality in the Berg River is a serious problem (92%), there was no agreement about when the problem started (range was between two to 20 years ago), nor was there agreement about whether the problem has improved, stagnated or got worse in the past years. Furthermore, there was also disagreement on the impact from the Berg River dam on the river, as well as the extent of other issues related to the water quality of the river (e.g., the issues of aquatic weed or salinity).[104] Hence, it points to the need to establish a common view regarding the status of the ecological system based on agreed and valid knowledge and systematic observation. Other studies (e.g., Crona and Bodin 2006; Sandström, 2011) have demonstrated that creating a common understanding about the SES is not a sufficient condition for AM. Sandström (2011: 294) for example emphasizes that "a common view regarding the status of the ecological system based on agreed and valid knowledge, systematic observation is a prerequisite for adaptability".

The analysis has shown that ecological knowledge is not well embedded and that in particular many of the core WMOs have limited access to ecological knowledge and which appears to negatively affect their commitment to the sustainable management of the river. The DWA, which is supposed to be an important knowledge source and transmitter, can currently not fill either of the two roles. While the work of consultancies, if systematically applied, could strengthen the DWA's knowledge generation capacities currently, their work is not applied with a larger holistic understanding of the catchment in mind. Furthermore, it needs to be noted that as long as a catchment-wide systematic monitoring program is not enforced and complemented by a functioning communication system, effective knowledge generation will remain a challenging task. In addition, the distribution of

[104] This may not just be resultant from the lack of valid ecological knowledge but also reflect the localized impacts experienced in differ localities in the catchment.

ecological knowledge and the development of a catchment-wide vision for the Berg River is hampered by the problem that context-specific decision-making tools such as the State of the River Reports (intended to be updated every four years) or other strategies are either nonexistent or completely out of date. These tools, when equipped with the most recent ecological knowledge and trends, could guide the decision-making of many organizations or at least provide a point of reference until a catchment management strategy has been established. Unfortunately, the last State of the River Report for the Berg is from 2004, and the new one intended for 2008 still not finalized.

5.4.4. Cross-boundary linkages: exploring the interaction across sectors and modes of governance

Given the definition of horizontal cooperation that this thesis advances, the focus on sectors and modes of governance for assessing cross-boundary interaction in the Berg management network is considered to be important. It is for this reason that these two types of cross-boundary linkages were assessed with help of the External-Internal (E-I) index function in UCINET. The E-I index (Krackhardt and Stern, 1988) has been introduced in Chapter 3 as a method for examining intra-group and inter-group (i.e. cross-boundary) ties. In the first analysis, organizations have been classified according to specified sectors, and in the second analysis, organizations have been assigned to one of the three ideal governance modes introduced in Chapter 2. In both cases, cross-boundary linkages were examined for information exchange (information network) as well as for collaboration ('collective action' network).

Important for the discussion below is to know that an E-I index value can range from 1 to -1. A value of 1 means that all ties are external (i.e. only cross-boundary linkages exist). A value of -1 means that all ties are intra-group ties (i.e. no cross-boundary linkages exist). A network that has an equal share of intra-group and cross-boundary linkages would have an E-I index value of 0. Below, the results of the calculations for the E-I Index at network and group level are discussed. A 5000-iteration permutation test was performed (see Section 3.1.3 for an explanation of the test).

Table 5-18 shows which organizations have been assigned to which sectors. In Table 5-19, organizations are affiliated with one of the three governance modes. It needs to be pointed out that these categories are rather fluid and that some organizations could easily be ascribed to more than one specific sector or mode. For highly difficult choices, the decision was based on the qualitative understanding of the organizations and their role in the Berg catchment as perceived by the researcher.

Table 5-18: Organizations organized according to governance sectors

Agriculture (AGRI) (#19)	Basic services for human well-being (BASIC) (# 11)	Water sector (WATER) (# 3)	Conservancy (CONSV) (# 9)	Research & consultancy (R&C) (#8)	Industry (IND) (# 3)	Other (OTHER) (#1)
IBs (14) WUA (1) DoA DoA_wc IB pollution Agri WC	Municipalities (9), DoH_wc DoLG_wc	DWA, WfW WQ task team	DEA&DP_wc WESSA CapeNature WWF BEMF BL SA NR RGDS AGC CWBR	CSIR Sanbi J.B. Anchor Aurecon Blue Science Wateright SW	WWs SB WQ Trust ST WQ Trust	OoP_wc

Table 5-19:Organizations organized according to governance modes

Hierarchy (#19)	Market (# 19)	Network (#16)
DWA	IBs (14)	WUA (1)
WQ task team	WWs	WESSA
DEA&DP_wc	Anchor	WWF
DoA	Aurecon	BEMF
DoA_wc	Blue Science	AGRI SA
Municipalities (9)	SW	BL SA
DoH_wc		NR RGDS
DoLG_wc		AGC
CapeNature		CWBR
WfW		CSIR
OoP_wc		Sanbi
		J.B.
		SB WQ Trust
		ST WQ Trust
		IB pollution
		Wateright

5.4.4.1. Cross-boundary linkages: Sectors

Table 5.20 shows that the information network with groups defined by sectors has an observed E-I index of 0.236, meaning that the proportion of ties among groups is higher than within groups. However, the observed E-I index is lower than the expected E-I Index (0.568). Indeed none of the permutation derived E-I values (see min. and max.) was as low as the observed (P <=0.000). Hence, while about 62% of the ties are external ties, the intra-group ties are greater than expected. This indicates a significant orientation towards intra-sectoral cohesion. The intra-sectoral cohesion is even stronger in the 'collective action' network. The observed E-I index of 0.082 is considerably lower than the expected E-I index of 0.568. While the proportion of intra-group ties (46%) is slightly less than the

external ties, none of the permutation derived E-I values (see min and max) were as low as the observed (P <=0.000).

Table 5-20: External-Internal (E-I) results for information exchange and collaboration with groups defined by sectors

*NW = network

	Observed			Permutation					
Network	**External**	**Internal**	**E-I (rescaled)**	**E-I expected**	**E-I Min.**	**E-I Ave.**	**E-I Max.**	**P≥ Obs**	**P≤Obs**
information exchange (Information NW, 288 ties)	0.618	0.382	**0.236**	0.586	0.306	0.588	0.847	1.000	**0.000**
Collaboration (collective action NW, 122 ties)	0.541	0.459	**0.082**	0.586	0.148	0.587	0.902	1.000	**0.000**

Table 5.21 provides information on how collaborative ties ('collective action' network) are distributed for each sector. While the different group sizes make a comparison impossible, the table still shows that most sectors (except IND and OTHER) have collaborative ties to other sectors.

Table 5-21: Intra-sectoral and cross-boundary collaboration rates for sectors.

The diagonal cells (grey) show the proportion of collaborative ties that organizations have to other organizations from the same sector (intra-sectoral collaboration). All of the diagonal cells highlight the proportion of ties organizations have to sectors other than their own (inter-sectoral collaboration).

	AGRI	**BASIC**	**WATER**	**CONSV**	**R&C**	**IND**	**OTHER**
AGRI (n=19)	0.65	0.09	0.04	0.10	0.12	0.00	0.00
BASIC (n=11)	0.26	0.22	0.10	0.32	0.05	0.05	0.00
WATER (n=3)	0.2	0.02	0.20	0.20	0.10	0.00	0.10
CONSV.(n=9)	0.21	0.25	0.08	0.42	0.04	0.00	0.00
R & C (n=8)	0.40	0.07	0.07	0.07	0.40	0.00	0.00
IND (n=3)	0.00	1.00	0.00	0.00	0.00	0.00	0.00
OTHER (n=1)	0.00	0.00	1.00	0.00	0.00	0.00	0.00

* AGRI =agriculture, BASIC = Basic services, IND = industry, WATER = water sector, R&C= research and consultancy, CONSV= conservancy

Tables 5-22 and 5-23 display the number of external and internal ties for each sector as well as the E-I index for each specified sector. It appears from Table 5.23 that the agricultural sector is the only one that has many intra-sectoral collaborative ties. (E-I index -0.308). However, the sector has also a considerable number of collaborative ties to other sectors. Hence, one could conclude that agriculture is a remarkably strong sector with strong internal collaboration (34 ties) while it is also well connected externally (18 ties). Similar relational patterns for the sector could be observed for information exchange (E-I index -0.360).

Table 5-22: Sector level E-I index: information exchange

Information network				
	Internal	External	Total	E-I
AGRI (n=19)	68	32	100	-0.360
BASIC (n=11)	10	43	53	0.623
WATER (n=3)	4	33	37	0.784
CONSV. (n=9)	14	33	47	0.404
R&C (n=8)	14	30	44	0.364
IND (n=3)	0	6	6	1.000
OTHER (n=1)	0	1	1	1.000

Table 5-23: Sector level E-I index: collaboration

'collective action' network				
	Internal	External	Total	E-I
AGRI (n=19)	34	18	52	-0.308
BASIC (n=11)	4	15	19	0.579
WATER (n=3)	2	8	10	0.600
CONSV (n=9)	10	14	24	0.167
R&C (n=8)	6	9	15	0.200
IND (n=3)	0	1	1	1.000
OTHER (n=1)	0	1	1	1.000

Also notable in Table 5-22 is the prominent role of the research and consultancy (R&C) sector with regard to information exchange in the Berg management network (14 internal and 33 external ties). However, this role as information provider does not translate to the same extent to collaborative ties externally as it does internally (see Table 5-23). Hence, the research and consultancy sector is not highly involved in inter-sectoral collaborative efforts. Considering that this sector is, in the context of the management of the Berg catchment, primarily represented by consultancies, the rather low involvement in collaboration is not surprising. Hence, consultancies are less inclined to provide their services without being remunerated for it.

5.4.4.2. Cross-boundary linkages: modes of governance

The observed E-I Index of 0.097 in Table 5-24 for the information network with groups defined by governance modes is significantly lower than the expected Index of 0.354. The network has significantly more internal ties than expected (P <=0.000). Consequently, this suggests a preference for establishing internal ties (homophily or intra-mode cohesion). In the 'collective action' network with groups organized by governance modes, the percentage of internal ties (54%) is slightly larger than the external links. The value for the observed E-I Index is -0.082 which stands in stark contrast to the expected E-I Index of 0.354. The tendency toward internal ties is strongly pronounced (p<=0.001).

Table 5-24: External-Internal (E-I) results for information exchange and collaboration with groups defined by governance modes

	Observed			Permutation					
Network	**External**	**Internal**	**E-I rescaled**	**E-I expected**	**E-I Min.**	**E-I Ave.**	**E-I Max.**	**P≥ Obs**	**P≤Obs**
Information exchange (Information NW, 288 ties)	0.549	0.451	**0.097**	0.354	0.097	0.352	0.583	1.000	**0.000**
Collaboration ('collective action' NW 122 ties)	0.459	0.541	**-0.082**	0.354	-0.180	0.354	0.852	1.000	**0.001**

Table 5-25 highlights the low level of cross-boundary collaborative linkages for actors belonging to the hierarchical mode and organizations belonging to the market mode. Both of these modes have a strong internal orientation. Organizations that are part of the network mode have a more even distribution of their collaborative ties. The low collaboration observed between market actors and actors belonging to the hierarchical mode (i.e. government organizations) corresponds with the qualitative data from the interviews. In this case, it became apparent that market mode actors do not view government organizations as reliable partners due to the perceived bureaucratic red tape and the inadequate capacities within those organizations.

Table 5-25: Intra-mode and cross-boundary collaboration rates for the modes of governance

The diagonal cells (grey) show the values for the proportion of ties that organizations have to organizations belonging to the same mode. All off diagonal cells are the proportion of ties that organizations from a specific mode have to organizations that are part of a different mode.

	Hierarchy	Market	Network
Hierarchy (19)	0.60	0.06	0.34
Market (19)	0.07	0.70	0.23
Network (16)	0.46	0.26	0.28

The two Tables (5-26 and 5-27) presenting the group level E-I index for the different governance modes show that market mode actors have a strong internal orientation with regard to collaboration (E-I index -0.400). However, they are externally oriented when it comes to information exchange (E-I index 0.211). Government organizations (hierarchical mode) have a strong internal orientation for information exchange (E-I index -0.203) as well as collaboration (E-I index -0.191). The high internal orientation could be a result of the vertical (i.e. hierarchical) relations among government organizations and their limited interaction with actors from other modes could be an indication that these actors find it more difficult to establish horizontal collaborative linkages.

Table 5-26: Group level E-I index information exchange relations (288 ties)

Information network				
	Internal	**External**	**Total**	**E-I**
Hierarchy (19)	74	49	123	-0.203
Market (19)	28	44	72	0.211
Network (16)	30	63	93	0.416

Table 5-27: Group level E-I index collaborative relations (122 ties)

collective action' network				
	Internal	**External**	**Total**	**E-I**
Hierarchy (19)	28	19	47	-0.191
Market (19)	28	12	40	-0.400
Network (16)	10	25	35	0.429

To summarize the two analyses on cross-boundary linkages: The collaborative relations in the Berg management network can be predominantly found within sectors. This tendency becomes even more visible when organizations have been grouped according to governance modes. Hence, a significant level of intra-sectoral cohesion and intra-mode cohesion can be observed. While the internal orientation with regard to sectors and modes is less pronounced for information exchange among the organizations involved in the management of the Berg River, it is still significant. Hence,

the inter-sectoral integration appears to be low in the network and while all three modes of governance affect the patterns of interactions in the network, it appears that organizations belonging to the hierarchical mode find it particularly difficult to establish collaborative ties with organizations from the network and market mode.

High levels of collaboration can be found within the agricultural sector. At the same time, the sector holds collaborative ties to other sectors. The observed significant collaboration within the sector is partially resultant from the collective action among the group of IBs but, as is shown with the help of the G-F brokerage method below, other actors such as the Department of Agriculture, Western Cape (DoA_wc) are also highly collaborative actors. Market actors have established many cross-boundary linkages for information exchange but they have primarily created collaborative linkages among themselves. Of the three modes, actors belonging to the hierarchical mode are the least collaborative and most of their collaborative ties are internal.

5.4.5. Individual actors and their role for fostering cross-boundary linkages

The previous section has provided a good understanding of cross-boundary linkages at the network and group level. This section is interested in identifying those actors that seem to bridge sectors or modes. Towards this end, the G-F brokerage role method that has been explained in Section 3.1.3.3 was utilized.

From the results of the G-F brokerage analysis below (Table 5-28) it appears that is in particular the Department of Agriculture, Western Cape, CapeNature, the Main IB but also the two district municipalities (WCDM, CWDM) which seem to fulfill important broker roles with regard to inter-sectoral integration. The DWA does not appear to contribute to intra- or inter-sectoral collaboration. Sectors that have the greatest number of brokers are agriculture and conversation.

Table 5-28: Key brokers within and across sectors based on G-F Brokerage method

Actors with the highest intra-sectoral brokerage scores signal an important role for intra-sectoral coordination whereas high scores for the Gatekeeper, Liaison and Consultant roles signal an important role for inter-sectoral coordination. [105]

Sector	Organization	Intra-sectoral brokerage (Coordinator)	Inter-sectoral Brokerage (Gatekeeper /Repr., Consultant, liaison)
AGRI	DoA_wc	2	23
	Main IB	154	22
	Lower IB	4	6

[105] Gatekeeper/ representative = actor acts as contact between members of his group and another group. Liaison = actor links two organizations that are members of different groups. Coordinator = links actors in its own group. Consultant = links two actors that belong to the same group but to which the actor does not belong.

	Tulbagh WUA	0	3
	IB pollution	0	5
BASIC	WCDM	0	9
	CWDM	0	12
	DS_M	0	3
WATER	DWA	0	1
	WfW	0	6
CONSV	CapeNature	6	31
	WWF	0	7
	BEMF	2	9
C &R	Wright	0	9

Table 5-29 list the scores of the most important organizations that seem to bridge modes of governance. It appears that the Main IB, CapeNature and the Department of Agriculture, Western Cape (DoA_wc) who already played important broker roles for sectors, are again the most important organizations. In addition, the BEMF seem to fulfill important broker role between the three governance modes. This suggests that BEMF is an effective platform that is able to enhance sectoral integration and as well as the coherence of governance modes.

Table 5-29:Key broker across modes of governance

G-F brokerage high scores for coordinator role signal an important role for intra-mode coordination whereas high scores for the Gatekeeper, Liaison and Consultant role signal an important role for inter-mode coordination.

Mode	Organization	Intra-mode brokerage (Coordinator)	Inter-mode Brokerage (Gatekeeper /Repr., Consultant, liaison)
Hierarchy	DWA	2	0
	DoA_wc	4	21
	WCDM	4	5
	CWDM	4	7
	CapeNature	10	26
Market	Main IB	130	34
	Lower IB	0	8
Network	Tulbagh WUA	0	4
	IB pollution	0	4
	Wright	0	7
	BEMF	0	12
	WWF	0	8

5.5. The role of influential actors

In the first part of the chapter two organizations, the DWA (in this case the Regional Office of the Western Cape) and the Main IB, were identified as the most central actors in the Berg management network (e.g., through the centrality measures). A number of reasons exist as to why the two organizations possess these central positions. The DWA occupies this position because of its legal/political authority. The Main IB, on the other hand, emerged as an influential actor because of its capacities to establish collaborative relations with other organizations. Additional analyses in the section on network cohesion and heterogeneity provided evidence that both actors differ in how they use their central positions in the network. The findings from the analyses are discussed below. This is done in view of the organizational characteristics (e.g., mandate and capacities) of the two actors.

The DWA has a specific mandate that enables proactive engagement in the Berg River catchment. The core functions of the regional office are to regulate water use and management activities and to ensure the protection of the Berg River. Furthermore, the National Water Act (1998) has assigned to the organization the role of a proto-CMA until the establishment of such an organization. That is, it has a specific obligation to coordinate actions among users of the Berg River and to provide a vision for the catchment. Yet, the investigation of the DWA`s role in the Berg catchment revealed that the organization struggles to fulfill its functions. This is, for example, supported by the SNA analysis which showed that the DWA's contribution to the production and transmission of ecological knowledge is currently minimal (section 5.4.2.).

Despite the fact that the DWA has relations to many organizations that are operative in the catchment, the DWA is unable to utilize these linkages because it is highly restrained in its organizational capacities. This became evident when the SNA revealed that the DWA does not play a central role in the collaborative efforts to address the issue of degrading water quality (expressed through the 'collective action' network, section 5.3.4.1.). At the same time, the DWA falls short of the necessary leadership that would be required to address effectively the issue of degrading water quality. Efforts led by the DWA, such as the WQ task team, lack the commitment to develop it into a constructive platform for concrete actions. This in turn prevents others from investing time and energy into the DWA's efforts. The cohesive sub-group analysis, for example, disclosed that several of the organizations that formally are members of the WQ task team do not acknowledge this platform as a collaborative practice (section 5.3.4.2.). From the evidence provided through the SNA and the qualitative understanding of the activities in the catchment, it can be concluded that the DWA is currently not able to contribute to the cohesion (e.g., through providing leadership or a vision) and heterogeneity (e.g., by transmitting new or important information and linking various organizations) that is required for enhancing opportunities for learning and collective action in the Berg catchment. It therefore seems reasonable to argue that at present the DWA operates as a gatekeeper rather than a broker in the network.

In comparison to the DWA, the mandate of the Main IB is more restricted with regard to the coordination of activities in the catchment. Its main objective is to ensure that the interests of the IBs and its members are protected. Therefore, the coordination of activities is primarily limited to the IBs. Despite this, the Main IB, as a powerful organization in the Berg management network, has to a certain degree contributed to cohesion and heterogeneity in the network. It has for example enhanced the cohesion among the IBs and strengthened relation to other actors such as the DWA and some of the local municipalities. Furthermore, the IBs, under the coordination of the Main IB, actively contribute to the knowledge generation about the river (e.g., through the monitoring system) and are also willing to share this knowledge with other organizations. By engaging more collaboratively with some of the local municipalities, the Main IB, through its pollution committee, also assists in strengthening capacities of some of the municipalities (e.g., sharing of water quality data, working jointly when pollution incidents occur).

This suggests that in comparison to the DWA, the Main IB is more able to utilize its central position. While the organization is willing to engage with the DWA and some of the municipalities on the issue of water quality, it is less willing to engage with other organizations on related issues (such as alien clearing) or to take up more management functions. Although the Main IB does not act as a gatekeeper, it might best be described as a highly strategic, self-interested broker willing to

contribute to cohesion and heterogeneity in the network as long as this enhances the interests of the IBs.

What neither of the central actors does is to deliberately coordinate actors to establish a common vision for the Berg catchment and its management. Yet, the need for coordinating actors who facilitate the establishment of a common vision and who can assist in coordinating specific actions became recurrently apparent in the investigation. This is particularly the case in the Berg River catchment where the issue of degrading water quality is multifaceted and many organizations with different interests and capacities are involved in the management of the catchment. The quantitative analysis of actor relations above demonstrated, in the example of the DWA, that political authority and legitimacy is a necessary but not sufficient condition to fulfill a coordinating role. If an organization does not have the required capacities (leadership and brokerage) to utilize its central position then this will lead to a dis-accreditation of its legitimacy and such actor can become a gatekeeper hindering other collective processes that might arise in the catchment.

While the Main IB is a key actor in the Berg catchment, it cannot fulfill the role expected of the DWA, nor is it willing to do so. The Main IB is a highly resourceful organization with a lot of influence over its member organizations whose interests are closely linked to the status of the Berg River. The IBs are therefore inclined to make important contributions to the management of the Berg River and may in this way even reduce the management burden on the DWA (e.g., through their own WQ quality monitoring system). However, the incentive structures for the proactive engagement of the Main IB (and all other IBs) in the Berg management network are rooted in market structures, i.e. in the export market and the related global food standards. As long as this is not complemented by other effective incentive structures (e.g., by the state) the IBs are unlikely to go beyond their immediate self-interests.

Despite the seemingly vital role of capacitated central actors, the analysis of the collaborative relations in the catchment also seems to suggest that the functioning of the Berg management network does not solely depend on the two most central actors. Other organizations also possess great potential to contribute to the required cohesion and heterogeneity. The cohesive sub-group analysis identified a significant number of organizations operative in the catchment that have organized themselves into collaborative initiatives through which they try to address issues relating to the water quality of the Berg River. It became further clear that several of those organizations (e.g., the WCDM, CapeNature, and the Lower IB) are actually important in fostering valuable linkages between the initiatives. They also play important roles in enhancing sectoral integration and the coherence of governance modes. By occupying these bridging positions in the network, they have a good understanding of the various activities in the network. They also have a demonstrated

willingness to collaborate with others and to successfully navigate sectoral interests and discrepancies among the governance modes. Consequently, they have the potential to contribute to the cohesion as well as heterogeneity of the network, i.e. their knowledge of, and engagement in, the different activities could assist in coordinating existing efforts. With access to different knowledge sources, they could also assist in enhancing the information on the status of the river system. Yet, so far, their bridging functions have not been acknowledged by the DWA, the Main IB, and other higher level decision makers. As a result, their actual influence on the dominant decision-making processes in the catchment/network is rather restricted. Furthermore, all of these organizations are quite constrained in their own capacities. They have to attend to other obligations and commitments inside and outside the catchment. This constrains their abilities to upscale their efforts.

5.6. Conclusion: Revisiting the chapter objectives

In this chapter, a SNA was used to examine the operational level of South Africa's water governance system. The aim was to achieve a better understanding of horizontal cooperation in complex governance arrangements and its effect on water management in the Berg catchment. Through the employment of various complementary quantitative analyses at the network, sub-group and individual levels, the four objectives that were stated in the beginning of the chapter were addressed.

Objective 1: The identification and description of the actor network at the operational level (i.e. the Berg management network)

The analysis showed that in the case of the Berg catchment the operational level is composed of a diverse group of organizations (including inter-organizational platforms that vary in their levels of formality). The high number of non-mandated organizations that are part of the actor network suggests that various incentive structures seem to exist that encourage different actors to contribute to the management of the catchment (section 5.2.). The information exchange and collaboration among the organizations provide clear evidence that water management is by no means simply a matter of a few government organizations (and their technical staff).

The 54 organizations that comprise the Berg management network possess complementary resources, skills, and types of knowledge that potentially could assist greatly in the effective management of the Berg catchment. The rather sparse interaction that the SNA measures revealed among the organizations is not surprising given the large number and the different stakeholder groups these organizations represent. Within the Berg management network, two organizations (the DWA and the Main IB) appear to occupy central positions in the network. Hence, these two actors, given their connections to other organizations in the Berg catchment, could theoretically enhance

the communication and collaboration among the organizations. However, while the potential capacity for AM appears to be high (with many learning opportunities and possibilities to work jointly) in the Berg catchment, the investigation into the patterns of interaction among the organizations showed that the realized capacity is extremely low which is evidenced by the poor management performance of the network. This is best exemplified by the issue of degrading water quality, the absence of an adequate water quality monitoring system, and the low level of rule compliance[106]. Further investigations into the information exchange and collaboration among the organizations found that the cohesion and heterogeneity in the Berg management network provide insightful explanations.

Objective 2: Assessing horizontal cooperation based on the two network characteristics cohesion and heterogeneity

Cohesion in the Berg management network was assessed by investigating quantitatively the interactions between specified core WMOs as well as by examining the extent to which the organizations comprising the Berg management network have self-organized to jointly address issues of degrading water quality, i.e. the presence of cohesive sub-groups, in other words, collaborative clusters.

Group density and centralization were important measures to better understand the patterns of interactions among and within the core WMOs. These measures showed that the interactions among the core WMOs are not sufficient for the effective sharing of water management responsibilities and coordinating actions in the catchment. For example, information exchange as well as collaboration among the core WMOs is extremely low (section 5.3.3.). Formal obligatory interactions exist, but for the most part these do not seem to contribute in their current form to meaningful information sharing and to effective management of the Berg River. The low level of interaction among the local municipalities was particularly alarming (section 5.3.3.2.).

The examination of the core WMOs also revealed that the IBs, as a stakeholder group, have a high self-organizing capacity which has enabled them to effectively engage in collective action and to build strategic linkages to other organizations from the network. The group of IBs organized around the Main IB has well established patterns of interaction which have been in existence for a long time. While formal relations among the IBs exists, strong trust relations are the basis of the cohesion within the group. This cohesion is strengthened and maintained through the coordinating activities of the Main IB. Yet, the cohesion and collective action within the group of IBs cannot compensate for

[106]Rule compliance is especially an issue with regard to water discharge and encroachment on the river banks (Interview S-3, S-8)

the sparse and inadequate interactions among all core WMOs. The consequences of the insufficient cohesion become visible in the absence of:

1. a common vision for the management of the catchment;
2. the lack of a common understanding of the Berg River and its ecological status;
3. a systematic plan of action to address the issue of degrading water quality (e.g., the inability to prioritize activities).

Three factors seem to hinder interaction among the core WMOs. Firstly, while the two identified central actors are among the core WMOs, they do not provide the leadership required for the coordination of actions and creating a common vision. The DWA shows almost no leadership characteristics. Its engagement in the network does not enhance communication among municipalities, nor is the DWA a central actor in the identified collective action initiatives (see e.g., Figure 5-11). The organization also does not appear to actively support any of the self-organizing efforts of other actors. The Main IB, on the other hand, shows strong leadership capacities. However, the organization uses its central position in the whole network and among the core WMOs to advance primarily the self-interest of the stakeholder group it represents (i.e. the IBs and commercial agriculture). Secondly, another hindrance to interaction is the complicated role of the local core WMOs (IBs and municipalities). They are not only managers but are also users and, at least some of them, polluters. In such circumstances, it is not easy to establish trusting relations or to increase the willingness to collaborate. Thirdly, the strong distinction between water resource management and water service management among the municipalities also negatively affects their willingness to engage more actively in the management of the Berg River.

The cohesive sub-group analysis detected several collaborative clusters through which some of the organizations from the management network attempt to jointly address the issue of degrading water quality. These collaborative clusters show that the need and willingness for joint action is high in the network. Potentially, these joint efforts could become the basis for nurturing trust and strengthening relations within the network. Yet, the qualitative understanding of the clusters also suggests that they differ in their performance. Overall it appears that the collective action efforts seem to be constrained by the lack of catchment-wide cohesion and the insufficient interactions among core WMOs. Both factors are critical for establishing a clear vision for the catchment and for linking and or up-scaling the collective action efforts.

The assessment of the heterogeneity revealed that high actor diversity, resources, and types of knowledge are currently not well utilized. The core-periphery analysis highlighted the lack of

integration of key water users and of stakeholders with a high dependency on the Berg River (section 5.4.1.). Also of concern is the fact that neither the production nor the distribution of ecological knowledge plays a critical role in the decision-making of the Berg management network. Hence, ecological knowledge is not well embedded in the actor network which negatively affects the problem-solving capacities and sectoral integration (agricultural water quality demands vs. urban water service provision) of core WMOs (Section 5.4.2.). While linkages across different sectors and between organizations that belong to different governance modes exist, these linkages are too limited to speak of inter-sectoral integration or of coherence of governance modes. This leads to the conclusion that the observed horizontal cooperation in the Berg management network does not currently allow for the required learning and collaboration to establish and maintain an adaptive water management system in the Berg catchment. Yet, the analysis also highlighted several opportunities how the situation could be improved. For example, the role of the identified bridging organizations (in terms of fostering collaboration across collective action initiatives, sectors, and modes of governance) should be acknowledged and supported by the central actors in the network or other higher level decision makers (section 5.4.4.). Although the DWA is currently a capacity constrained organization, if the organization focused its efforts on strengthening its leadership responsibilities and investing in its learning capacities, this would be beneficial for the network and would reduce the management burden of the DWA.

Objective 3: The influence of the cohesion and heterogeneity in the Berg management network on the learning and collective action capacities of the organizations

The SNA provided a clear picture that the learning and collective action opportunities in the Berg management network are currently constrained by the patterns of interactions among the organizations.

The learning of the core WMOs is restricted by their inadequate access to scientific and experiential ecological knowledge. The low cohesion among the core WMOs also has hindered them in learning about each other's needs and constraints. This in turn makes it difficult to establish more trusting relations and to find common interests. Valuable learning platforms seem to have been established within some of the identified collaborative clusters (e.g., the Estuary Forum or initiatives within the alien clearing cluster). Yet, the generated knowledge remains largely contained in the platforms and does currently not contribute to catchment-wide learning processes. This is partially the case because the two identified central actors are not inclined to facilitate learning processes at catchment scale. For example, the few public meetings organized by the DWA have been limited to information provision, rather than leading to meaningful participation and deliberation.

The existing cohesion is not conducive for catchment-wide collective action nor is it sufficient for concerted action among core WMOs. Localized collective action, that manifests itself in the collaborative clusters, has a lot of potential but needs to be embedded in larger processes as existing management issues are too complex to be dealt with at one level or scale.

Yet, it also needs to be highlighted that the management network is not completely dysfunctional. It signifies rather that influence has shifted from conventional decision makers such as the DWA to other resourceful organizations that have been able to utilize their relational capacities. To illustrate: the problem of degrading water quality has been a concern in the Berg River catchment for many years. Yet, it was primarily through the joint actions taken by the IBs that the problem became openly acknowledged by political decision makers in the three spheres of government (i.e. the municipalities, provincial government, and national government (the DWA)[107]).

The investigation into the management of the Berg catchment also revealed that the pressure and influence of the IBs have not been enough to create a catchment-wide strategic plan of action to systematically address the problem of degrading water quality. While a common problem definition within the Berg management network is evident (i.e. water quality is viewed a serious problem in the catchment), this problem definition is largely shaped by the knowledge and interests of the IBs. Consequently, the multifaceted issue of degrading water quality might be too narrowly defined. What seems to hamper a holistic problem definition is a lack of integration of the ecological knowledge (including systematic monitoring and evaluation), the weak engagement of other critical water users, as well as a lack of joint iterative learning processes upon which localized as well as catchment-wide collective actions can be build.

Objective 4: New insights into sectoral integration and the coherence of governance modes through a relational approach

Although the quantitative analyses were not able to assess coherence of the modes of governance or sectoral integration in great detail, they were able to demonstrate that a considerable level of interplay between sectors exists. Overall, the tendency to form intra-sectoral ties is currently predominant in the Berg management network. The agricultural sector seems to be well organized and embedded in the network. To what extent cross-sectoral integration could be strengthened once the network has been able to establish a common vision and management strategy for the catchment needs to be seen.

[107] While the regional office of the DWA Western Cape has its jurisdiction in the province, it is still part of a national department.

The quantitative analyses also showed that all three governance modes affect the interactions in the Berg management network. Surprisingly it was market mode actors that have been identified as the most collaborative organizations (section 5.3.4.). At the outset of this research many interviewees indicated that it appeared that the only effective drivers to push for higher water quality in the catchment came from market structures (e.g., global food standards). However the SNA demonstrated in the example of the IBs that the market incentives (loss of export market) were only able to become effective drivers when they were complemented with strong relations among the affected actors (i.e. IBs which coordinate their internal affairs through a network-like governance mode). This suggests a mutual beneficial interaction between market and network modes.

6. Chapter: Collective action and self-organization in the Berg River catchment

Chapter 5 identified with the help of a formal SNA the organizations that are involved in the management of the Berg catchment, and described how the regular pattern of interactions among them has affected the management of the Berg River. Gaining a more detailed understanding of the structure and composition of the Berg management network provided insights into how the cohesion and heterogeneity within the actor network has affected learning processes and collaboration among the organizations involved in the management of the catchment. In other words, the formal SNA made it possible to demonstrate how the network structure has shaped the performance of the actor network in terms of AM.

This chapter assesses horizontal cooperation from a qualitative perspective through a focus on collective action. The primary objective of Chapter 6 is to identify constraints affecting collective action and the capacity to self-organize for organizations involved in the management of the Berg catchment. As part of the SNA analysis several collaborative clusters (i.e. cohesive sub-groups) were identified in Chapter 5. These clusters comprise specific collective action initiatives which are the focus of this chapter. Ostrom's eight design principles are applied to examine the constraints that affect collective action within the initiatives as well as catchment-wide collective action. It is further argued that through the design principles, the extent of AM in the Berg catchment and the existence of a functioning (polycentric) water governance system can be probed.

The chapter is organized in the following way: First, the two management issues of pollution and alien-invasive vegetation that threaten the Berg catchment are described from the perspective of collective action problems. The subsequent section reports on six selected collective action initiatives. To allow for a comparison of the initiatives, the motivation for, internal dynamics within, larger context and potential contributions to management functions are highlighted for each initiative. To estimate the level of catchment-wide collective action, findings from two workshops that had been organized by the researcher are incorporated into the analysis. This is followed by a discussion on the individual design principles. The purpose is to reveal key constraints to collective action and to demonstrate how the individual design principles assist in determining the robustness of the existing governance arrangements of the Berg catchment. The chapter ends by highlighting the role of agency in creating robust governance arrangements.

6.1. The two management issues

To illustrate the need for collective action in the Berg catchment, but also to point to the challenges associated with collective action in common pool resource systems, two management issues are

described as so-called collective action problems (sometimes also referred to in the literature as commons dilemmas). These two management issues are degrading water quality (see Chapter 4) and the invasion of alien vegetation in the riparian zone. They are threatening the sustainability of the Berg catchment and illustrate that the existing governance arrangements are not able to effectively manage the catchment .

Degrading water quality is a multifaceted problem in the Berg catchment. Chapter 4 highlighted that one of the major factors that has contributed to the pollution of the Berg River is the inadequate municipal water service infrastructure and the poor management of the infrastructure. Confronted with the in-migration of job seekers from other parts of the country, and struggling with the maintenance and upgrading of waste water treatment as well as sanitation infrastructure, some of the local municipalities have become major polluters in the catchment. In addition, due to the slow and patchy implementation of water reform, characterized by insufficient law enforcement and the lack of monitoring activities, other users have also, intentionally and unintentionally, contributed to the pollution problem (e.g., through agricultural runoff and industrial discharge) (Interview I-5, I-12).

The other major issue in the Berg catchment, alien-invasive vegetation, is a significant environmental problem for many of South Africa's riparian ecosystems (Richardson et al., 1997).[108] Invasive trees and shrubs (such as eucalyptus and black waddle) but also aquatic weeds (e.g., water hyacinth, water lettuce, parrots feather) impede the functioning of the Berg River and its ecosystem services. Studies have shown that the invasion of alien vegetation in riparian systems leads to decreased surface water runoff and groundwater recharge as well as decreased river flows, increased biomass and more intense fires and consequent erosion (Chamier et al., 2012).[109] Chamier et al. (2012) state that invasive alien plants do not only affect water quantity but also water quality. The reduction in river flow, for example, contributes to increases in the concentrations of nutrients and pollutants, which in turn "contribute[s] to eutrophication processes resulting in potentially toxic algal bloom" (Chamier et al., 2012: 346).

Both pollution and alien-invasive vegetation are complex, interrelated problems involving different actors and different property rights systems (private and public land ownership). Addressing these

[108]It has been estimated that the reduction in surface water runoff amounts to about 7% (ca 3,300 Mm3) of the national total (Le Maitre et al., 2000, cited in Chamier et al., 2012).

[109]Many species of invasive alien plants, especially trees and shrubs, have higher evaporation rates than indigenous species do and, therefore, use more water than the vegetation they replace. "The increased biomass and evapotranspiration rates associated with invasive alien plants arise because of their greater height, root depth and senescence, compared to the native species that they replace."(Chamier et al., 2012: 345, citing Calder and Dye, 2001).

issues effectively necessitates the contribution and commitment of many actors that agree to work jointly. Alien-invasive vegetation, for example, can only be managed successfully through a systematic strategy in which private land owners, relevant government departments (e.g., DoA, DEA, municipalities) and conservation organizations are engaged. Without coordination, collective action, and follow-up, alien vegetation re-grows, and land users re-infest each other's property, thereby wasting the scarce funding that is available for alien clearing (Interview I-3, I-5). Furthermore, the clearing of alien vegetation requires a lot of technical expertise with regard to the restoration of the riparian zone, follow up clearing, and the management of biomass (Interview I-4, I-6 I-4, I-25). Therefore, close cooperation between research institutions, government agencies (operative as implementing agents) and landowners, and an adaptive 'learning by doing' approach are critical building blocks for the successful management of the issue. Similarly, the pollution problem also requires the contribution and close cooperation of many actors from various administrative levels and sectors. It is imperative that the main causes of pollution (especially challenges related to waste water treatment plants and informal settlements) be addressed jointly, and that innovative solutions be found for strengthening law enforcement and monitoring in light of existing resource constraints.

Despite the need for collective action in the Berg catchment, the limited possibility of excluding actors from the use of the water resources (abstraction, discharge and land management practices) or from the benefits gained through the joint efforts of others, motivates behavior such as free-riding (expressed in the Berg catchment by the non-participation in the maintenance or conservation of the water resources). Chapter 5 mentioned several factors that seem to reduce the willingness for collective action in the Berg catchment. Among them are the varying dependencies on the water resources and the perceptions of stakeholders of their impact on the water resources, especially with regard to land management practices. Chapter 5 furthermore highlighted that the perceptions that others will not commit to their responsibilities, as well as uncertainty regarding the long term assurance of benefits of certain stakeholder groups (e.g., insecurity of IBs with regard to the property rights), are also factors impeding joint action. Together, these factors forcefully undermine the willingness and commitment to collective action in the Berg catchment. Despite this rather bleak picture, collective action efforts do exit in the Berg catchment. These efforts are the focus of this chapter because they have the potential to make significant contributions to AM in the Berg catchment and for addressing the two management issues more effectively.

Chapter 3 introduced Elinor Ostrom's comprehensive work on collective action in common pool resource systems. There it was mentioned that Ostrom, based on a large number of empirical case studies, has developed a theory of how actors can successfully engage in collective action and overcome the social dilemmas described above. This theory is captured in the eight design principles

which express conditions under which trust and reciprocity for societal cooperation can be established. The design principles were described in great detail in Chapter 3. However, since they serve as guiding reference points for investigating the collective action initiatives in this chapter, they are summarized as a reminder in Table 6.1.

Table 0-1: The eight design principles as important conditions for societal cooperation (adapted from Ostrom, 1990; Cox et al., 2010)

Principle 1:	***Well-defined boundaries:*** **a. community boundaries** **b. resource boundaries**
Principle 2:	***Congruence between appropriation and provision rules and local conditions*** **a. cost must be perceived as at least equal to benefits** **b. rules must match local conditions**
Principle 3:	***Collective-choice arrangements***
Principle 4:	***Monitoring*** **a. Monitoring of environmental condition** **b. Monitoring of the human environment interaction**
Principle 5:	***Graduated sanctions***
Principle 6:	***Conflict-resolution mechanisms***
Principle 7:	***Minimum recognition of rights***
Principle 8:	***Nested enterprises***

6.2. Identification and description of collective action in the Berg catchment

As part of the SNA analysis, four collaborative clusters were identified which can be understood as indications of higher levels of collaborative activities. These clusters serve as a starting point for the investigation of collective action and self-organization in the Berg catchment. From those four clusters, six collective action initiatives were selected. While three clusters equate to singular collective action initiatives (the Berg Estuary Management Forum, the Water Quality task team and the Irrigation Board initiative) the cluster containing organizations that partake in alien-invasive clearing comprise several collective action initiatives. Three collective action initiatives were selected from this cluster to explore in more detail. They are the 24 River initiative, the Lower Berg initiative and the Adopt a River Stellenbosch initiative.

The six initiatives were selected because they represent the scope of collaborative efforts that exist in the catchment. They furthermore could potentially become important platforms that foster cross-boundary linkages and AM in the Berg catchment. However, as it will become clear in the subsequent sections, the performance of the initiatives differs greatly. Some could even be described as non-functioning.

The collective action initiatives are not easily comparable as they differ in their formality, composition, number of actors, and stage of development. Therefore, different methods were considered to gather information on the evolution and performance of the initiatives. Empirical data on the initiatives was generated through follow-up interviews with organizations participating in the initiatives, qualitative data from the SNA survey, participant observations in meetings of some of initiatives as well as through the analysis of minutes from previous meetings.[110] In addition, government reports and strategies were consulted to understand the formal reasons for establishing some of those initiatives.

What follows is a detailed description of the six selected initiatives. To assist with the assessment of the initiatives and their individual and joint contributions to AM of the Berg catchment, they have been organized according to the following themes: motivations, internal dynamics, the larger context, as well as realized and potential outcomes with regard to AM. The reader is referred to Chapter 3 for more information on the themes. The occurrence of Ostrom's design principles are highlighted for each initiative through brackets [Principle x (+/-)] with a (+) indicating a positive expression and (-) a negative expression. The design principles are then further discussed in section 6.4.

6.2.1. The irrigation boards (IB) initiative

The IBs have been introduced in Chapter 5 as core WMOs. The SNA also identified them as a cohesive sub-group with a strong group identity [Principle 1a (+)]. The SNA showed further that the IBs, primarily through their internal organization and the linkages to experts and decision-makers, have asserted influence on other organizations and decision-making processes. This has enabled the IBs to frame the issue of degrading water quality as an economic issue and to put degrading water quality high on the political agenda. However, it took several years and different strategies, ranging from threats of legal actions to the establishment of scientific reports, to finally get the necessary political attention (Interview I-22). The main strategy pursued by the IBs was to show how the loss of the agriculture export market would affect the economy of the Western Cape (in terms of loss in GDP and potential jobs in the agricultural sector and in the related manufacturing and service industries) (Interview I-13). This strategy was quite successful as it did raise concern among various government

[110] See Appendix 6.1 for a list of organizations whose qualitative data informed this chapter.

departments who otherwise would have discarded the issue as an environmental or agricultural problem.

The Berg River Main IB (Main IB) was established in the early 1970s as an overarching body to coordinate the activities of all IBs receiving water from the Berg River (Interview I-13). There are twelve Irrigation Boards/Associations represented on the Main IB. These are all entitled to draw water from the Berg River [Principle 8 (+)] (Interview I-26).[111]

6.2.1.1. Motivation

When the IBs realized that the problem of degrading water quality in the catchment could become a serious threat to their economic existence and that actions taken by individual IBs or farmers were not enough to exert pressure on political decision-makers, the IBs decided to engage in strategic collective action (Interview I-22). One of the activities was the formation of a pollution committee to which they also invited regional scientific and water sector experts. The aim was to gain legitimacy and credibility and to provide evidence for their claims that degrading water quality is a threat to the region's economy and that the municipalities are among the major polluters (Interview I-22).

The interviews with the chairmen of the IBs revealed that the widespread perception that their current property rights and related benefits are under threat was for many IBs another motivating factor to engage in a joint group effort (Interviews I-19, I-21, I-15, I-3). Many white commercial farmers believe that national land and water reforms could significantly curtail existing rights and benefits. It therefore seemed important to speak with one voice to ensure that the interests of the IBs would not be ignored in the government-led transformation process. Several IB chairmen stated further that water is one of the most constraining factors for increasing their agricultural productivity (Interviews I-19, I-17, I-15). Hence, current and future access to adequate water quantity and quality is vital for the sustainability and growth of the farms. The chairmen believe that being well organized as a group and being very proactive on the issue of degrading water quality increases their lobbying potential and makes it more challenging for the government to just impose new regulations upon them (Interviews I-27, I-22). The fact that the IBs have over generations developed strong informal and formal relations has kept the transaction costs for engaging in collective action on the issue of degrading water quality very low. Hence, existing trust relations as well as formal organizational

[111] The Main IB manages water releases from the Government Water Schemes from Theewaterskloof Dam, Berg River Dam and Voëlvlei Dam. Water use by individual water users and irrigation boards are controlled on behalf of the DWA. The Main IB acts as billing agent to recover water resource charges from water users and payment thereof to the DWA (interview I-26).

structures (e.g., the annual joint IB meetings and regular meetings of the chairmen) prompted this stakeholder group to invest additional resources into collective efforts concerning water quality of the Berg River.

While several interdependent factors motivated the IBs to self-organize, the most significant driver for the IBs to move their collective action beyond their water use management function (i.e., water distribution and financial management) was the threat that the farmers would lose access to the export markets, a core market segment for their products (Interview I-21, I-22, I-13 I-26,). Associated with this was the fear that should the water quality issue prevail or even worsen, they no longer could afford the rising costs associated with treating the polluted water prior to irrigating their crops (Interview I-15, I-14).

6.2.1.2. Internal dynamics

The IBs have a long history in the catchment area. Many of the irrigators belonging to the IBs have possessed and cultivated agricultural land in the catchment for several generations (Interview I-17). Over time and within the legislative framework of the Water Act of 1956, they have developed a self-regulating governance system through which they coordinate the distribution of water from the Berg River and related management activities [Principles 3 (+), 2b (+)] (Interview I-15). Chapter 5 highlighted the fact that the group of IBs is very homogeneous in terms of their interests, values, needs and ethnicity. It seems that because of the perceived threat to their current rights and benefits, the group identity may even have grown stronger in the past years.

The analysis in Chapter 5 showed that most activities are coordinated through a central actor (the Main IB). This enables the group to be very effective and efficient in terms of information exchange and the prioritization of activities. While the Main IB is the key decision maker and has much freedom to act, major decisions always require the consent of the chairmen of all IBs [Principle 3 (+)]. The pooling of resources allowed the organizations to distribute the cost for undertaking specific measures such as water quality monitoring or the attendance of public meetings[Principle 2a (+)] (Interviews I-13). The group of IBs have established their operation rules in accordance with the functions assigned and delegated to it in terms of the Water Act of 1956 and the National Water Act of 1998 through which they coordinate their activities [Principle 3(+)].

The interviews as well as the SNA survey revealed a common problem definition among the IBs with regard to the issue of degrading water quality. According to them, the root causes of the problem lie with the municipalities and other key provincial and national government departments that are currently not able to enforce existing regulations or do not adequately fulfill their management functions. Because of the strong group identity among the IB members, all organizations are fully

committed to the initiative. Yet, the cohesion within the group is not always perceived as beneficial. Fear of negative media coverage has sometimes prevented farmers and IBs from publishing results of pollution incidents and water quality of the Berg River [Principle 5 (-)]. However, many pollution incidents have been regularly reported to the DWA. (Interview I-26).

6.2.1.3. Larger context

Having established strategic linkages to other organizations, the IBs are well positioned to influence decision making in the Berg catchment [Principle 8(+)]. Chapter 5 showed how they have access to ecological knowledge and policy information at the catchment level which in turn allows them to use their collective action strategically to advance their interests. Nevertheless, the IBs have also come to the realization that no matter how well organized they are as a group, as long as the larger management system remains inadequate, their efforts to improve the water quality in the catchment and the management of the Berg River will remain constrained. It also needs to be noted that while the IBs are influential stakeholders in the catchment, their acceptability has been questioned because they are not transformed into WUAs with the participation of all sectors with an interest in the Berg River. The transformation to WUAs has been delayed because of the institutional realignment process within the DWA. They are however still legal statutory bodies with regard to water legislation [Principle 7(+)].

6.2.1.4. Uptake of management functions

Realizing that that the DWA as well as other government organizations are currently not able to effectively manage the catchment area, the IBs have started to take on a more active role. Hence, they no longer just regulate the activities among IBs and their members (e.g., water distribution, cost for water infrastructure maintenance etc.). They have engaged in the systematic monitoring of water quality in the Berg catchment (e.g., through the pollution task team committee) [Principle 4a and b (+)]. At the same time, the IBs remain reluctant to take on even more functions because of the uncertainty with regard to their long term benefits from the catchment (Interview I-13). Hence, the institutional uncertainty regarding the land and water reform processes (including the pending transformation of IBs to WUAs) reduces the willingness of the IBs to make costly long-term investments. Furthermore, the IBs continue to have little trust in the DWA (national and regional) and its capacities to provide the required guidance for the water sector (Interview I-22). In the past years, the DWA has been unable to provide a clear vision for the management of South Africa's water resources. Indeed, the DWA has on several occasion changed its discourse and often not acted on its promises articulated in the public stakeholder meetings. This has unsettled the IBs as well as many other actors. There is also the suspicion among the farming community that government departments only try to delegate responsibilities and costs to users and local managers without

providing the necessary support and without the government departments fulfilling their responsibilities (Interviews I-15, I-13). These factors have reduced the willingness of the group of IBs associated with the Main IB to contribute more actively to other management activities such as alien clearing.

6.2.2. The Berg Estuary Management Forum (BEMF)

The Berg Estuary Management Forum was established in 2009 as part of the GEF and South African government co-funded Cape estuaries program (Interview I-23). The para-state conservation agency CapeNature, host of the Cape estuaries program, leads the estuary management process. The aim was to develop systems and processes to improve the management of the estuary and in so doing ensure the protection of the estuary that is in the lower reaches at the coast.[112] The forum consists of representatives from DEA, DAFF, DWA, DEA&DP, CapeNature, Bergriver Municipality, West Coast District Municipality (WCDM), local tourism, Bird Life SA, WESSA, Anchor Environmental, Cape Westcoast Biosphere Reserve (CWBR). Participation is governed by points set in the agenda but members that participate on a regular basis are CapeNature, representatives from conservation groups (such as Bird life SA and CWBR) and a representative from local tourism.

6.2.2.1. Motivation for establishment

In addition to the formal advisory role mentioned above, the intent was to create through the BEMF a platform which enables better coordination between various government departments and which allows for a more participatory and inclusive management approach involving local users and other relevant stakeholders (Interviews I-23, I-7). Members of the BEMF stated that the ability to receive and exchange information about relevant legislation and trends concerning the estuary, the pooling of resources, the ability to impact local decision-making processes, and the establishment of a joint vision and rules for the estuary were factors motivating them to participate in the forum (Interviews I-28, I-29, I-30). Most of the actors participating in the BEMF were of the opinion that the fragmented management approach previously practiced had led to the deterioration of important ecosystems in the estuary and that a joint and coordinated effort was needed to secure the long term sustainability of the estuary.

6.2.2.2. Internal dynamics

The running of the BEMF is financed by the WCDM as well as CapeNature. The role of the chairman is currently carried out by the CapeNature representative. He is also the driving force behind the BEMF.

[112] While estuary management forums are not legally required with regard to specific legislative processes in South Africa, the Integrated Coastal Management Act (2008) does provide for advisory bodies that can be set up to advice the district municipalities via the municipal coastal committees.

The members meet on a bi-monthly basis to discuss issues relating to the estuary. One of the larger tasks of the forum, and which is currently underway, has been the development of an estuary management plan and its implementation. The BEMF, through its members, monitors development trends and practices in the estuary. It also tracks the fulfillment by various government agencies of their roles and duties related to the estuary [Principle 4a and b (+)]. More recently, the forum has started to be involved in water quality monitoring activities.[113]

The BEMF is a highly democratic platform in which decisions are based on consensus [Principle 3 (+)]. If larger disputes cannot be resolved within the BEMF, then experts or relevant policy makers are invited to the BEMF meetings to provide more detailed information on a specific issue (Interview I-23). The findings from participant observation and the interviews suggest that the BEMF has developed into a joint learning platform. Many of the participants stated that they have learned a lot about the estuary, either through the information exchange with other forum members or through the contributions of invited scientific experts (Interview I-29, I-30). In addition to using the meetings for deliberation, the BEMF has developed a good communication system through which all members (even those that rarely participate) are informed about the meetings and the recent developments relating to the forum or the estuary. The common problem solving approach and joint vision for the estuary among the members is reflected in the estuary management plan.

The BEMF has benefited a lot from the leadership of the chairman and the dedication of the representative of the WCDM. However, the high commitment of the other members becomes apparent through the ways in which tasks and responsibilities are shared in the forum. Almost all activities are done on a voluntary and honorary basis. Several members, however, have pointed out that some of the local government organizations could be more proactive and show more commitment. Although state and non-state actors are treated as equal partners in the meetings, non-state actors have complained that they are investing a lot of time and effort without any formal acknowledgment or compensation. Representatives from government organizations, on the other hand, get paid for their time (i.e., the meetings are part of their job description and they get also reimbursed for their travel time). Consequently, non-state actors feel that the costs and benefits of participating in the forum are not equally distributed [Principle 2a (-)] (Interviews I-29, I-30).

Another potential weakness of the BEMF observed by the author is that the meetings take place during working hours. This makes it difficult for some stakeholders to attend. They simply cannot

[113] The WCDM, through an agreement with the DWA (national), are conducting monthly salinity runs as per the National Estuarine Management Programme. (interview I-7).

afford to take time off from work. It is for this reason that it is mainly retired citizen that make up the majority of non-state actors in the forum. Of concern also was that no representatives of poorer, more marginalized communities are part of the forum [Principle 1a(-)]. One reason mentioned is that they are not well organized and that some of those communities are only represented through local municipal councilors. Currently, the forum is highly dependent on the chairman and his leadership. A more formal institutionalization of the forum (e.g., through the hiring of staff) would significantly reduce this dependency. The two identified champions in the forum, the chairman and the representative from the WCDM, are constrained in their current capacities (Interviews I-7, I-23). They, like most forum members, have many parallel commitments that require their time and resources.

6.2.2.3. Larger Context

Although the BEMF brings together a very diverse group of organizations which have developed, through the platform, a shared understanding of the estuary and who can successfully negotiate the differing interests and needs of the various stakeholders, the forum is not well linked to other initiatives in the catchment [Principle 8(-)]. It simply lacks the resources and capacities to do so. A related obstacle is that estuary management forums are not yet formally recognized by legislation (ICMA or NEMP) and government in general [Principle 7(-)] (Interview I-7).[114]

The lack of embeddedness in larger decision-making processes of the Berg management network has already been captured through the SNA analysis in Chapter 5. Interviews with organizations outside the estuary also affirmed the impression that many organizations do not view the estuary as part of the Berg River system (Interviews with representatives of the DWA, DEA&DP, upstream municipalities). As a consequence, the forum remains ignored by most of the decision makers and initiatives in the Berg catchment [Principle 8(-)]. This is problematic for the BEMF and the sustainability of the estuary. The forum depends on information about the Berg River for its own decision making and prioritization of activities. Furthermore, many of the activities that happen upstream ultimately affect the estuary. If the forum is not well connected, it cannot report issues that are caused by upstream activities.

Perhaps the greatest concern is the long-term sustainability of the BEMF. The forum has grown in its tasks and responsibilities. But as shown above, many activities rely on the voluntary commitments of its members. This is neither sustainable nor does it allow for the forum to effectively fulfill all its management activities or to assist other key management organizations such as the local

[114] Estuary Management forums were taken out of the ICM Bill when it became an Act. The Estuary Management (Chapter 4) of the ICM Act does not make any reference to Estuary Management Forums, only estuary management plans (EMP) (interview I-7).

municipality in the management of the estuary. Several members stated that while lead organizations (DWA and DEA&DP) have a legislative obligation to provide financial support to the forum and the municipality, so far they have failed to do so [Principle 7(-)](interviews I-7, I-23).

Another potential point of conflict could be the fact that the forum has only an advisory function in the management of the estuary [Principle 3(-)]. Specific responsibility for the management of the estuaries has been delegated to local municipalities (Celliers, 2009), or in cases where the municipality struggles to fulfill its responsibility, it is the district municipality that takes over some of the functions (Interview I-7). Although the forum has established a good working relationship with the local municipality, commitment especially from senior officials, is still missing (Interviews I-7, I-23). This becomes apparent through the rather passive participation of the municipal representatives in the forum. It was pointed out by the municipal officials that without a dedicated budget on the Municipal IDP for estuary and coastal management, the incentives remain very low for most municipalities to become responsible estuary managers (Interview I-7).

6.2.2.4. Uptake of management functions

The forum is a vital platform for the management of the estuary. It has brought together a diverse group of people that through the forum can work together and share their resources and generate new knowledge that allows them to effectively address emerging issues or conflicts relating to the estuary or the forum. Through the monitoring of the activities of different players and socio-economic trends as well as ecological changes in the estuary, the forum is vital for knowledge production, information dissemination and transparency. As such, the forum could make important contributions to a catchment-wide monitoring system [Principle 4a and b (+)]. The forum has also been able to engage the local municipality, creating a sense of ownership and shared responsibility. The municipality has realized that the forum can become an important support structure and assist the resource-constrained municipality in the management of the estuary. Finally, the forum plays an important role in advocating that the ecological reserve flow requirements are met [Principle 2b(+)] (Interview I-23). The forum's engagement with the DWA has resulted in improved flows, especially with regard to base flows reaching the estuary.

6.2.3. The Water Quality task team

The task team is a forum coordinated by the DWA (regional office Western Cape). The primary objective of the task team is to coordinate the actions of all government departments that have some level of responsibility relating to the Berg River. The forum is also intended to engage major users from the catchment area. Participants in the forum are representatives from local and district municipalities, the DWA, several provincial government departments, and major users such as the IBs and the fruit growers industry.

6.2.3.1. Motivation

The initial driver behind the establishment of the forum was the Office of the Premier of the Western Cape. The former premier became aware of the issue of degrading water quality partially through the lobbying of the IBs (Interview I-31). He then commissioned a study in 2009 to assess the problem. The output was a formal report (BRTR, 2009) which lists key impacts and causes of the degrading water quality as well as provides several recommendations.[115] In the process of establishing who was responsible for the pollution problem and who should take the leadership in addressing the problem and coordinating the actions of the various departments, a dispute between the provincial and national government became apparent(Interview I-31, I-32). In the end, it was the DWA that took over the coordination of the forum.

6.2.3.2. Internal dynamics

The largely unresolved dispute resulted in low political will by the lead agencies (DWA RO WC and Provincial Government) to commit to the forum. The consequence was that the task team rarely met in the period between 2009 and 2012.[116] Not surprisingly, the lack of interaction hindered the possibility of constructively negotiating perceived conflict of interests [Principle 6(-)]. It also made it impossible to develop a common problem definition and to establish a systematic plan of action to address the problem of degrading water quality [Principle 3(-)]. Some of the local organizations (municipalities and IBs) voiced their frustrations about the lack of leadership by the DWA and provincial government (Interview I-22, I-33). Some interviewees went even so far to say that they felt this was just a pretense that something is done about the issue at a higher level political level. The observed lack of political will to transform this forum into a working platform was also echoed by representatives from several provincial government departments (Interview I-31, I-34).

The quantitative analyses in Chapter 5 provide evidence for the lack of interaction within the task team (See section 5.2.2). The findings showed that the patterns of interactions in the task team are weak. Some of the task team members (IBs and some municipalities) did not even indicate that they have collaborative relations with the task team [Principle 1a(-)].

6.2.3.3. Larger context

Being unable to establish a clear vision and a plan of action, this inter-governmental forum is also not in the position to take on a catchment-wide coordinating role or to link to other collaborative efforts in the catchment area [Principle 8(-)]. The lack of involvement of the Task Team in the Berg management network also became apparent in the SNA.

[115] Until now the report has been used as a point of reference for discussing the status of the river.
[116] Minutes of the Water Quality task team meetings (2009-2013).

As mentioned previously, the issue of degrading water quality is a highly complex problem. In the South African context it is closely related to housing and sanitation issues. Many factors that are contributing to the issue of degrading water quality are therefore outside the jurisdiction and sphere of influence of those responsible for the management of the Berg River. Finding the optimal level and scale for addressing the issue adequately remains elusive. Such a problem necessitates engaging with different levels and scales simultaneously. However, without leadership and vision at the catchment scale, the issue will continue to be addressed in a fragmented manner.

6.2.3.4. Uptake of management functions

As indicated above, the task team in its current form does not add any value to the management of the Berg catchment area. Indeed, it may actually obstruct the emergence of alternative collaborative efforts that involve decision makers from different administrative and political levels (local, provincial and national). Nevertheless, many governmental organizations and stakeholders are of the opinion that this type of forum is vital for the management of the Berg catchment and that it is essential to transform the Water Quality task team into a functioning platform. The need for coordinating actions, especially among the various government departments, is tremendous and many organizations are of the opinion that the water quality issue can only be effectively addressed if the political level at which the task team is located takes a leadership role (Interviews I-32, I-26, I-33, I-1). While it might be possible to develop a clear vision and strategy for the catchment at a lower level, only through the committed involvement of higher levels of decision-making can such vision and strategy be implemented.

6.2.4. The 24 River initiative

The 24 River initiative is a collaborative effort between an IB (the 24 River IB, which is not member of the IB initiative discussed above), the conservation organization WWF SA, the government program Working for Water (WfW), the para-statal NGO CapeNature and the Department of Agriculture Western Cape. The purpose of the initiative is to pool resources to clean a section of the river of alien vegetation. More specifically, the initiative has set out to clean 250 ha at an estimated cost of R6 mill.

6.2.4.1. Motivation

Like degrading water quality, alien clearing is a problem that is very costly and requires a systematic approach. Even though the overall intent of the unique partnership was the pooling of resources, each of the organizations has engaged in the partnership for slightly different reasons. WWF saw in the initiative a good opportunity for conserving natural vegetation in a region characterized by intense agriculture. For WfW and Department of Agriculture, Western Cape, it was important to create some notion of ownership and responsibility on the part of the landowners so that they are more willing to maintain follow-up clearing activities (Interviews I-3 ,I-25). The farmers saw in the

partnership an opportunity to get financial support with the clearing, to work jointly with experts, and to safeguard future water rights (Interview I-18). Furthermore, being proactive in alien clearing enables the farmers to have more influence on how, where and by whom the clearing is done.

6.2.4.2. Internal dynamics

The 24 River IB has been the champion behind the initiative. It is represented by the chairman and has 42 members (who each have an average farm size of 100 ha). In the initiative, WfW functions as the lead agent and WWF SA provides additional financial resources and expert advice on river rehabilitation. CapeNature is involved in the training of personnel in the removal of alien vegetation. The Department of Agriculture, Western Cape has been providing more indirect support in the form of advice based on previous initiatives (Interview I-6). After three years the initiative is still in its planning stage. The delay is mainly due to the long bureaucratic procedures within government organizations such as WfW. Despite these constraints, regular communications and meetings among the organizations have led to trusting relations (Interview I-25). Everyone involved has learned a lot about the others, the specific constraints in which each organization has to operate, and what it means to engage in a collaborative project involving such a diverse group (Interview I-3, I-25). Transparency and open communication has helped to better illuminate why the implementation of the project has been delayed for such a long time. Constraints not only exist within the government organizations. It was, for example, quite challenging for WWF to secure the necessary funding required for the clearing project. The representatives also needed to convince their headquarter that the project will meet the conservation requirements of WWF (Interview I-25). This highlights the fact that the different objectives and mandates of the organizations (such as public works programs vs. river rehabilitation vs. more water for agricultural production) need to be carefully negotiated and deliberated. Crucial for navigating through sometimes conflicting objectives has been the establishment of interpersonal relations as well as access to ecological information on the extent of the problem (Interviews I-18, I-25). This in turn enabled the establishment of a common problem definition. Furthermore, it made it possible to find ways to best match and utilize resources and organizational mandates [Principle 3 (+)]. Through the division of tasks and the engagement of the land-owners, ecological and social monitoring can be achieved at low transaction costs [Principle 4a and 4b (+)]. WWF will be responsible for the ecological monitoring, and the irrigators will ensure that all landowners fulfill their commitments (Interviews I-18, I-25).

6.2.4.3. Larger context

Long delays and bureaucratic red tape within the government agencies have significantly hampered the initiative (Interviews I-18, I-3). It was, for example, only with difficulty that the IB could be accredited as an implementing agent [Principle 7 (-)]. The hold-up of actions made it difficult for the

IB chairman to keep other farmers committed to the initiative (Interview I-18). Another challenge is that the representatives involved in the initiative have sometimes limited influence over higher level decision-making processes within their own organizations. A key constraint in the case of WfW is, for example, that the program as a whole does not have a clear vision and strategic plan of action (Interview I-3). The leadership and vision absent at the national and provincial level in turn hampers the development of strategic action plans at catchment and sub-catchment level [Principle 8 (-)].

6.2.4.4. Uptake of management functions

While the initiative is a small project, still in its early stages and only focusing on a tributary of the Berg River, it has much potential to contribute to a more systematic and adaptive management of the catchment. The project creates important linkages between different sectors (e.g., conservation, agriculture and government departments) and also allows for a more equal distribution of costs for alien clearing [Principle 2a (+)]. This enhances the willingness of farmers to take some ownership and responsibility in alien clearing, which in turn increases the likelihood that the farmers will continue with the follow-up maintenance. It therefore could be argued that the initiative has great potential in fostering the self-governance capacities at the sub-catchment level while at the same time ensuring that the self-organization is in line with sustainable management objectives.

Alien clearing necessitates long term partnerships. Only a systematic learning by doing approach that takes into consideration the particular ecological and social context upon which management practices and rules of engagement are adjusted will ensure that the issue is effectively addressed . Many lessons can be learned from the project and the lessons should be taken back to the participating organizations so that future initiatives are less constrained by the obstacles that led to the delays in the 24 River initiative.

6.2.5. The Lower Berg initiative

Similar to the 24 River initiative, the Lower Berg initiative is a unique partnership composed of the Lower Berg IB (also part of the IB initiative), the West Coast District Municipality (WCDM), WfW and Department of Agriculture, Western Cape.

6.2.5.1. Motivation

The partnership started very informally after a water hyacinth outbreak in the Misverstand Dam in 2009 (Interviews I-27, I-35). To coordinate action and speedily address the outbreak, an action committee was created between the Lower Berg IB, individual farmers, the WCDM and Department of Agriculture, Western Cape. These collaborative efforts have developed into a working partnership which can easily be activated if necessary.

6.2.5.2. Internal dynamics

The initiative has been championed by the Lower Berg IB but the leadership is split between the Lower Berg IB and the Department of Agriculture, Western Cape (Interview I-27). The committee meets on a regular basis to discuss and address issues relating to alien vegetation that may occur in the Lower Berg [Principle 3 (+)]. The activities are no longer confined to the monitoring and control of aquatic weeds but also include the clearing of alien trees in some parts of the lower Berg River (Interview I-35). Motivated by the success of the initiative, some farmers have even started to clear on their own sections of the river beneath the Misverstand Dam. While the initiative has remained largely informal, regular information exchange in form of periodic meetings ensures that good working relationships are maintained (Interview I-7). The initiative is greatly valued by all organizations because it provides a mechanism by which individual resource constraints can be overcome through the pooling of resources (Interview I-4). This in turn has led to a more balanced distribution of costs [Principle 2a (+)].

6.2.5.3. Larger context

The initiative has experienced obstacles similar to those encountered by the 24 River initiative. The long bureaucratic procedures within government organizations are the biggest obstacle for responding promptly to emerging issues and for taking on management functions such as monitoring the river or systematically clearing alien species (Interview I-4). The initiative has accrued substantial knowledge on handling aquatic weeds; however, this knowledge has not been communicated to other initiatives or organizations even though the problem of aquatic weeds is also an issue in several other parts in the catchment.

6.2.5.4. Uptake of management functions

Through the initiative, the organizations have been able to develop a good monitoring system and early response strategy in the lower Berg catchment [Principle 4a (+)]. Unfortunately, the initiative is not well linked to other efforts to establish a monitoring system for the whole catchment [Principle 8 (-)]. The initiative further demonstrates that small projects that include private landowners are very important and that there is a need to build upon them. A representative from the Department of Agriculture, Western Cape expresses the impact of the project in the following way:

> "These projects are generally more sustainable because the landowner has invested time and money and will therefore take care of his "investment" by doing the required follow-up clearing and applying of herbicide. If landowners regard alien clearing as a government function and liability they will neglect the area that was cleared and the problem will be exacerbated by the initial alien-clearing project." (Interview I-35)

6.2.6. Adopt a River Stellenbosch

The final initiative that will be discussed is the Adopt a River Stellenbosch initiative. The initiative is part of a larger national program which has been started by the Minister of the DWA with the aim of cleaning up polluted rivers by employing unemployed community members (Interview I-2, I-36).[117] The Stellenbosch initiative is based on a Memorandum of Understanding between the Stellenbosch Municipality and the Minister of Water Affairs. The platform includes various departments from the Stellenbosch Municipality, representatives from local business and community groups, as well as officials from the provincial departments and DWA.

6.2.6.1. Motivation

With this partnership, the DWA, RO, and WC intended to get the communities more involved in addressing the pollution problem as well creating more accountability and leadership within the municipality.

According to the interviewed representatives from Stellenbosch Municipality, the municipality envisioned that it could, through the initiative, address the pollution problem more systematically and access additional financial resources (Interview I-36). Some of the municipal departments further hoped that the initiative could help to overcome internal political infighting as well as to obtain the necessary support from senior officials within the municipality (Interview I-8, I-9). Because of the perceived crisis situation concerning the rivers in the Stellenbosch Municipality, local stakeholder groups showed great interest in engaging the initiative. Prior to the initiative, the municipality had not taken any leadership in addressing the pollution problem or establishing platforms to coordinate actions and form partnerships with other stakeholders.

6.2.6.2. Internal dynamics

The Stellenbosch Municipality took over the leadership of the initiative and in the beginning the platform showed a lot of potential for initiating a plan of action through which the pollution problem could be systematically addressed. An institutional structure (including regular meetings and specific task teams) was established, and commitments to collectively address the issue of pollution were high on all sides [Principle 3 (+)]. But after the chairman, who was well positioned in the municipality and who led the process, left the municipality the platform started to fall apart. The position of the chairman was given to another representative who lacked the required leadership capacities and vision. Many meetings in the second half of 2012 and 2013 were canceled at short notice. Without

[117] The Stellenbosch Municipality has some of the most polluted rivers in the region. Although most of the rivers fall outside the Berg catchment, some upper areas of the catchment are within the municipal boundaries and towns like Franshoek have a direct impact on the water in the Berg.

continuity in leadership the platform was neither able to establish a holistic problem definition nor deliberate on how the problem could be addressed [Principle 3 (-)].

It became apparent that the short-term interest of the municipality in accessing funding for public works job creation measures and using the initiative as a political platform to show that the municipality is addressing the pollution problem started to be predominant. This destroyed the opportunity for the initiative to become a constructive platform for deliberation and strategic action. At the start of the initiative many stakeholder groups and different municipal departments believed that through the Adopt a River program the various players and stakeholders could create a joint understanding of the extent of the pollution problem and work collaboratively on a feasible plan of action that could be realized through the pooling of resources. Another disappointing experience was that municipal officials that had an interest in moving the initiative forward did not get the necessary formal support from senior officials [Principle 7 (-)](interview I-8). The lack of political will by the municipality has alienated many stakeholders as well as officials within the municipality that genuinely were trying to make the platform work through a collective effort.

6.2.6.3. Larger context

For several years political infighting within the municipality has inhibited its functioning. This has negatively impacted the day-to-day activities and planning of the various municipal departments and also created a very non-collaborative culture between different departments [Principle 6 (-)] (Interview I-8, I-10). The initiative was created in a context of many urgent problems that needed to be addressed. Without careful guidance (DWA and the municipality) and clear leadership the initiative could not develop a vision and prioritize activities [Principle 8 (-)]. Indeed, the platform was used to advance the self-interests of a few dominant players (the municipalityshould you list the other players?) without giving enough space for other actors and alternative ideas.

6.2.6.4. Uptake of management functions

The platform has failed to improve the coordination of river management within the municipality. However, in the first phase of its establishment, the platform has helped to create a better understanding of the pollution problem and on the constraints within the municipality. More trusting relationships started to emerge but all of this came to an abrupt halt after the chairman left. This highlights the need for visionary leadership which is not biased in the interest of one particular actor but which can bring together different stakeholders and help create a common problem-solving approach for the issue at hand. Another important lesson for this collaborative effort is that platforms need time to develop problem-solving capacities. It is therefore crucial to only focus on a few tangible tasks and not to overwhelm the platform with too many management tasks.

6.2.7. Catchment-wide collective action: insights from workshop findings

As part of the research the author organized two workshops with the intent of getting a better sense of the cooperation between the initiatives and the constraints specific to catchment-wide collective action. The first workshop ('champions' workshop) brought together organizations that, based on the SNA analysis, play a critical part in the overall management of the catchment.[118] This workshop had the intent of discussing current and future environmental threats in the catchment and of identifying current barriers to a more sustainable management of the Berg catchment. A second workshop ('alien' workshop) was held with key organizations involved in alien-clearing activities in the catchment. Although alien-clearing projects at sub-catchment level have been quite successful, the findings from the SNA survey and the investigations into the 24 River and Lower Berg initiatives suggested that clearing activities continue to be poorly coordinated at catchment scale. The overall aim of the 'alien' workshop was to elicit key constraints to the development of an integrated strategy for alien clearing in the catchment, to learn jointly about the different clearing projects and partnerships, as well as to share experiences and challenges relating to the collaborative efforts.[119]

While each workshop had specific objectives and targeted a slightly different audience, the workshops provided similar results on the topic of constraints to catchment-wide collective action. The discussions in the two workshops showed clearly that the organizations involved in the management of the Berg catchment did not share a common understanding of the Berg catchment.[120] The lack of shared understanding is a serious impediment to prioritizing activities and for establishing catchment-wide collective action. Access to information on the management issues (scientific data, existing strategies and lessons learned) and an inclusive monitoring system were highlighted as key obstacles. The absence of a guiding vision for the Berg catchment, inadequate strategic leadership by the DWA and other higher level organizations such as WfW as well as the missing of an interactive decision-making tool (e.g., a joint website) are factors that were identified

[118] Those targeted were so-called catchment champions (i.e., those attempting to contribute to AM in the catchment and key players based on their mandates).

[119] Detailed summary reports for each workshop are provided in Appendix 6.2.

[120] The participatory group modeling exercise in the 'champions' workshop, for example, revealed that while each organization has specific expertise on the Berg catchment, many workshop participants had differing, and sometimes limited, understanding of the Berg River system and its functioning. The difference in understanding was not as pronounced in the alien-clearing workshop. In particular the implementing agencies (WfW, CapeNature, Department of Agriculture, Western Cape and the district municipality) have a lot of ecological knowledge expertise on alien clearing. However, the discussion showed that most of the organizations raised questions regarding the magnitude of the alien invasion in the catchment. Hence, a lot of ambiguity about the extent of the problem and the required costs exists among the organizations.

as additional stumbling blocks for creating the necessary cross-boundary linkages and for establishing nested governance structures. As a consequence, many initiatives, but also individual organizations, continue to work in silos with little knowledge of the activities of other initiatives. This fragmented approach limits the success of the specific initiatives and reduces the problem-solving capacities with regard to the two management issues, pollution and alien vegetation.

The joint discussions and the sharing of experiences in the workshops also demonstrated how difficult it is to collaborate because of the diffuse responsibilities and mandates of the various organizations. These challenges, it became clear, can only be overcome through close interaction, processes of deliberation and a supportive institutional structure (support and guidance by higher level decision-making levels) and learning-oriented organizational cultures (which allow for a certain flexibility on interpreting mandates and moving beyond pre-defined self-interests). Both workshops turned out to be a highly valuable joint learning experience for the researcher and the participants and also demonstrated the enthusiasm and willingness among the participants to cooperate. However, because none of the key players (e.g., DWA and WfW) saw themselves in the position of taking on a leadership role, the ideas and planned activities articulated in the workshops quickly dissolved.

6.2.8. The presence of the design principles in the collective action initiatives

Table 6-2 provides an overview of how the design principles feature for each initiative. Not surprisingly those initiatives that provide positive evidence on most of the design principles are also the better performing initiatives in terms of improving the relations among the organizations and in terms of contributing to jointly to management functions.

Table 0-2: Results from the presence of the Ostrom's design principles for the collective action initiatives.

A cell with a (+) means the design principle is achieved, a (-) the design principle is not achieved, a (+) → (-) the design principle is no longer being achieved. Where (-) / (+) are present in a cell, findings could be interpreted in both directions. Note that while statements could be made for almost all principles listed in the table (exception n/a) only the most important design principles are found in the body text of section 6.2.

Design principles (Principles)		*IB Initiative*	*BEMF*	*WQ task team*	*24 River Initiative*	*Lower IB Initiative*	*Adopt a River*
Principle 1	a. Group boundaries	+	-	-	+	+	-
	b. Resource boundaries	+	+	+	+	+	+
Principle 2	a. Cost -benefit	+	-	-	+	+	-
	b. local conditions	+	+	-	+	+	-
Principle 3	Collective-choice arrangements	+	+/-	-	+	+	+ → -
Principle 4	a. Environmental monitoring	+	+	-	+	+	-
	b. social monitoring	+	+	-	+	+	-
Principle *5*	Graduated sanctions	-	+	-	*n/a*	+	-
Principle *6*	Conflict-resolution mechanisms	+	+	-	+	+	+ → -
Principle *7*	Minimum recognition of rights	+	-	-	-	+	-
Principle *8*	Nested enterprises	+	-	-	-	-	-
Leadership		+	+	-	+	+	+ → -
Learning processes		-/+	+	-	+	+	+ → -
Self-organized		+	*n/a*	*n/a*	+	+	*n/a*
Externally initiated		*n/a*	+	+	*n/a*	*n/a*	+
trust		+	+	-	+	+	-
Going beyond organizational self-interest		-/+	+	-	+	+	-
Uptake of management functions		+	+	-	*n/a*	+	-

It is interesting to note is that despite South Africa's progressive water legislation that provides ample opportunity for engagement and option generation (Stuart-Hill and Schulze, 2010; Dent,

2010< Colvin etal.,2014), the self-organizing efforts observed in the Berg catchment are not the result of enabling conditions. They have emerged in response to a perceived governance crisis situation at the catchment scale. Hence, the lack of effective governance at the catchment scale has motivated the desire for self-organization and self-governance at sub-catchment level. This has led to the more proactive engagement of some organizations which previously saw management of the Berg River as the sole responsibility of the DWA. However, by revealing key constraints that inhibit social cooperation and that affect the success and the sustainability of the initiatives, the next section will demonstrate that the capacity to transform the self-organizing efforts into effective governance arrangements remains limited.

6.3. Identifying key constraints to collective action and reflecting on the robustness of the governance arrangements

In this section, key constraints to collective action are assessed through the lens of Ostrom's eight design principles. Discussing each principle individually, the section furthermore inspects the extent of AM and polycentric governance in the Berg catchment. Doing so reveals important insights about the robustness of the existing governance arrangements that have emerged from horizontal cooperation.

Principle 1a & b: Well-defined actor and resource boundaries

Multiple demands on the catchment's water resources and the ways in which various practices affect the water resources make it difficult to define who is affecting the water resources to what extent and who should be participating in addressing management functions or issues.

Initiative based

The most clearly defined actor and resource boundaries, i.e., who is eligible for membership, could be observed within the IB initiative. In other words, the initiative has a closed membership with only regional IBs being able to become full members. While the pollution committee (including the participating experts) is part of the initiative, its role is restricted to that of an advising body. Not surprisingly, the IB initiative has also the strongest group identity, which was made evident in the strong cohesion detected in Chapter 5. This cohesion has led to a similar problem definition, and the possession of the same values and interests. All other initiatives have a more open membership. That is, actor boundaries are more inexplicit. Furthermore, the collaborative relations are still fragile. Hence, unlike in the IB initiative, trust and social capital must still be fostered.

Both situations are not without shortcomings in the Berg catchment. The closed membership observed in the IB initiative and the tendency to only engage in very strategic partnerships that advance the self-interest of the IBs hinders some of the individual IBs' engagement in collaborative

relations with organizations of different kinds. The ego network analyses in Chapter 5, Section 5.3.1 demonstrated that the 24 River IB, which is not a member of the IB initiative, has collaborative relations to several organizations of various kinds. The relations of most of the IBs that belong to the IB initiative tend to be restricted to the Main IB and the IB pollution committee.[121] Hence, the IBs that are part of the Main IB may be less adaptable to local changes as they have limited opportunities to learn and collaborate with other organizations operating in their localities. The open membership that characterizes all other initiatives results in the challenge of deciding whether or not an actor should take part in collective action. Furthermore, important players that are crucial for addressing the issue at hand cannot be easily forced to participate. Others may simply lack the authority or the ability to exert the needed social pressures on these actors to participate.

Catchment wide

The analysis of the initiatives shows that boundaries in complex regional SESs are not easily identified. Group boundaries as well as resource boundaries (including the boundaries concerning the two management issues which are resultant from several interlinked factors) will for the most part remain fluid. However, boundary specification is important for developing strategic action and assessing cost-benefit distribution as well as for clarifying roles and responsibilities (e.g., Armitage et al., 2008b). Based on the experiences of the initiatives it seems that deliberation processes within the initiative which, if complemented by open membership, could assist in the task of identifying, transcending and where necessary renegotiating relevant boundaries. However, as Ostrom (2009a) cautions, a clear distinction must be made between carefully defined boundaries that may change because of changing circumstances or new findings and ridged boundaries. Furthermore, the literature on complex SESs suggests that fluid boundaries are not as big a problem when nested enterprises (vertical and horizontal nestedness) exist (Termeer et al., 2013). That is, initiatives may be location specific even though the problem needs to be addressed at a larger scale. As long as the smaller unit is part of larger efforts, the initiative can still be effective. In other words, difficulty with fluid boundaries can be partially addresses through nestedness (design principle 8) and deliberation.

Principle 2: Congruence between appropriation and provision rules and local conditions

The initiatives showed clearly that collaboration and AM come at a significant cost. This cost must be openly acknowledged and made transparent. Where organizations perceive the cost of engaging in the management of the catchment and in collaborative efforts as too high, incentive structures

[121] The only exception in this group is the Lower Berg IB. While it is part of the IB initiative, it only joined the initiative more recently. Prior to joining the other IBs it was operating more independently and established collaborative relations to other organizations in the catchment.

provided by external (often higher-level) actors must be provided (e.g., tax subsidies, additional financial support, technical and ecological advice). In all initiatives it became clear that cost refers not only to the resources a specific organization contributes to the collective action. It also entails the time and effort needed for the deliberation and negotiation process itself and costs for gaining access to important information for decision making.

Initiative based

In the case of the IB initiative, the cost-benefit ratio is perceived as fair and transparent. All IBs make financial contributions to the Main IB which then uses the money to finance specific activities which benefit all IBs. The cost-benefit distribution in the other initiatives is less straight-forward and often needs to be negotiated among members. In policy and scholarly circles, participatory governance platforms have been promoted as new effective governance mechanisms (Reed, 2008; Mostert, 2003). However, the experiences of the BEMF and even the Adopt a River Stellenbosch show that the institutionalization and long-term sustainability of those platforms is often not well thought through in the planning processes. Several initiatives rely currently to a large extent on honorary and voluntary commitments, especially where they involve non-state actors. For example, members of the BEMF serve as secretary or take on other logistical tasks (such as minute-writing, etc.). Given the extent of the issues they are attempting to address, many initiatives will need to develop more institutionalized structures (e.g., hiring of staff, development of a business plan). Only such measure can ensure that they are able to balance cost and benefits in the future. Interestingly, the 24 River IB initiatives and the Lower Berg initiative also demonstrate that deliberative and open learning processes can assist in distributing the management cost more evenly.

In most of the initiatives, local organizations struggle with the task of taking on more management responsibilities without receiving the necessary support from higher level organizations. Just because organizations are competent or contribute to key management functions (e.g., the IB initiative or the BEMF) does not mean that they should be burdened with additional tasks without the required support. This is particularly the case when organizations are burdened with issues that need to be dealt with at a larger scale or higher level. In the long run, such an approach will erode the willingness and capacities of competent organizations to contribute to the provision of services for public benefit. Hence, the need for financial and non-financial incentive structures becomes apparent.

Catchment-wide

The institutional uncertainty concerning the Berg catchment (in particular the unfinished establishment of the CMA, the slow transformation process for WUAs and the incomplete water allocation reform) have significantly increased the perception of various stakeholders that risks, and therefore costs, remain currently higher than the expected benefits. Without clear guidance and

assurance from the DWA (national) and other spheres of national and provincial government, organizations are not sure as to whether their projects and joint activities will be supported and legitimized by higher level decision-making processes. Consequently, the commitments to increasing investments in the management of the Berg catchment and for up-scaling collective action remain low.

Because of the lack of a holistic understanding of the Berg catchment and its functions, many stakeholders continue to maintain a flawed perception of their level of dependency on the water resources from the Berg River. Dependency is primarily framed in terms of dependency for drinking water, industrial water use and irrigation. Too often the costs it would take to have to use alternative water sources are not incorporated, nor are the consequences considered if vital ecosystem services can no longer be maintained. Because of this contorted perception many organizations assume that the benefits of contributing to the joint management are not worth the effort.

Principle 3: Collective choice arrangements

Many studies have shown that those that are affected by the rules should be able to participate in rulemaking and their modification (Agrawal and Gibson, 1999). This is also the case for the Berg catchment. Participation in rulemaking not only increases the legitimacy of the specific activities (e.g., an alien-species clearing initiative that includes farmers). It also provides an avenue for defining and dealing with specific constraints as well as adjusting rules for changing ecological or socio-economic conditions. Hence, through collective choice arrangements rules become more enforceable and effective.

Internal rulemaking:

The better performing initiatives have been those where everyone participating in the initiatives could also contribute to the rulemaking. However, the initiatives may sometimes not include all relevant actors (e.g., in the BEMF, small scale and subsistence fishermen are missing, and in the Adopt a River Stellenbosch the informal settlements as well as local IBs are not adequately represented). Any rules that are established within the initiatives may therefore not be adhered to by those stakeholder groups.

Another observation that the author made during the meetings of some of those initiatives (e.g., Adopt a River Stellenbosch) is that some participants (e.g., municipal councilors) are not familiar with the science and policy terminology used in these meetings. They voiced concerns that they did not feel knowledgeable enough on the subject of water management and therefore preferred to keep quite in the discussions even when they were of the opinion that decisions contradicted their own

interests. This is a situation that has been highlighted by other studies too (e.g. Goldin, 2010; Colvin et al., 2008).

Rulemaking within the larger governance context.

The self-governance that some of the initiatives aspire has to take place within the constraints of existing legislation and policy frameworks. In other words, the rules of the initiatives, which determine their interactions with other organizations (e.g., rules of engagement, conflict resolution, distribution of roles) as well as interaction with the catchment area (specific management activities), have to be established within the constraints of institutional arrangements in which the various organizations are embedded. While it is critical for the initiatives that rules are adjusted to existing constraints and that certain room for experimentation and flexibility is provided, this is not easily achieved. The flexibility of many organizations is too often cumbered by their specific organizational mandates. This makes it difficult to make adequate adjustments to the local context and capacities. Furthermore, initiatives that are trying to apply a learning-by-doing approach (based on the monitoring and evaluation of previous actions) frequently realize that existing rules cannot be easily adjusted because of the institutional rigidity within their own organizations. Institutional rigidity has especially been an obstacle in the alien-clearing projects. It appeared furthermore that in the Berg catchment it is particular government organizations who continue to struggle to adopt a learning-by-doing approach and more flexible rules. A final point that needs to be made is that without access to information about ecological conditions and trends, the initiatives may not adequately adjust their management rules in accordance with the ecological changes in the catchment.

Catchment wide

As long as there are no functioning catchment-wide platforms in which relevant stakeholders are represented, creating collective-choice arrangements at this level is not feasible. The water quality task team which is supposed to focus on the entire catchment could potentially represent such a platform. But the current lack of deliberation within this initiative and the top-down approach pursued by the DWA do not allow for joint rule-making.

If a workable catchment strategy or at least a river management plan existed, then this would provide at least some prospect for balancing continuity and flexibility in the catchment area. Self-organizing efforts and flexible rulemaking at sub-catchment level could then take place within the parameters set by the strategy. Hence, mechanisms (such as a guiding strategy) can ensure that the rules and collective action activities at the sub-catchment level are consistent with larger public policy goals and the intended objectives (e.g., to secure the sustainability of its water resources and equitable access for all relevant stakeholders).

Principle 4: Monitoring

In the case of the Berg catchment, monitoring seems to be one of the most critical principles that could assist in the realization of collective action and the fostering of trust and reciprocity. The monitoring of actors and their practices as well as the monitoring of the ecological changes and trends is vital in several ways. A monitoring system can provide a holistic understanding of the current status of the catchment or the issue in question (e.g., extent of pollution or invasive vegetation). Such an understanding is a prerequisite for designing effective plans for and prioritizing specific activities. Furthermore, the monitoring of the practices of the organizations engaged in the management of the Berg catchment enhances trust levels among the collaborators.

Initiative based

The BEMF, the IB initiative, and the Lower Berg initiative have established effective monitoring systems that enable them to monitor environmental changes as well as social activities. Through the monitoring systems, participants in these initiatives have also gained valuable ecological knowledge. Joint evaluation of the monitoring activities within the initiatives has also provided valuable learning opportunities. Yet, these learning opportunities have been inhibited by the limited access to data on socio-economic and ecological changes at catchment scale.

Catchment wide

The absence of a comprehensive monitoring system was pointed out by many stakeholders as perhaps the biggest obstacle to creating an adaptive and functioning management system in the Berg catchment. Currently, neither environmental changes (e.g., adequate and continuous monitoring of water quality changes in the riparian zone) nor management and user practices (land use changes in the riparian zone) are adequately monitored. Furthermore, data from existing monitoring activities are often not user-friendly or easily accessible to most organizations. As a consequence, a lot of redundant and incomplete information that is based on speculation rather than systematic scientific studies[122] and monitoring activities circulates among the organizations in the Berg catchment. Therefore, the pervasiveness of existing issues and their causes cannot be effectively determined.

A catchment-wide monitoring system would be of great assistance to the various collective action initiatives with regard to knowledge generation and diffusion. It allows the evaluation of how existing measures not only affect a specific locality but also the larger system. At the same time each

[122] The issue in the Berg catchment is not so much the lack of scientific studies but rather the accessibility and capacity to interpret these studies for stakeholders and managers.

initiative, through its own monitoring activities, can make valuable contributions to the catchment-wide monitoring system. In this way an open and transparent communication system is established which can also help in the distribution of monitoring costs. Furthermore, overlapping and complementary monitoring activities can present checks and balances which in turn could enhance the legitimacy of the generated knowledge. For such a system to function, an adequate communication system must be established among the monitoring organizations. A communication system is not only important for the distribution of generated data but also for deciding which ecological and social indicators need to be measured, how and by whom. Given the large number of demands on the catchment's water resources and the many ecological processes that comprise the catchment, agreeing on the purpose and content of the monitoring system is not a straightforward matter. It necessitates deliberation and a systematic engagement of all involved in the management of the Berg catchment. Investing in an inclusive monitoring system that benefits from the plurality of contributions and which is utilized for joint learning and knowledge generation can become an important bridging tool that helps to establish collaborative linkages across levels and scales. It could also be used to increase the linkages between the scientific knowledge producers and core WMOs (see Chapter 5).

Principle 5: Graduate sanctioning

In the context of the Berg catchment, graduated sanctions need to be considered in relation to overall rule enforcement as well as in terms of the compliance with rules agreed upon within the initiatives.

Initiative based

The reasons for breaking rules (whether the inability to fulfill agreed upon commitments or engage in unsustainable management practices) are often multifaceted in the Berg catchment. Resource constraints, lack of education regarding the potential consequences of certain practices on the water resources, but also sheer disregard of existing rules because of weak rule enforcement mechanisms, have started to shape decisions regarding rule conformity in the catchment. It is therefore critical to openly discuss within the initiatives the reason for non-compliance and how the problems could be best resolved. This again requires transparency regarding one's own actions and constraints, open communication as well as regular interactions. Another challenge for those participating in the initiatives is that they have little influence over other organizations that contribute to the problem at hand but that are not part of the initiative. Hence, the need for access to a higher level conflict resolution mechanism becomes apparent.

Catchment wide

Currently, many organizations are of the opinion that the lack of enforcement of environmental legislation in the Berg catchment negatively affects their efforts to address the two management problems. Insufficient monitoring and the fact that enforcement agencies rarely prosecute wrong-doing (e.g., discharge of pollutants or solid waste into the river) has encouraged some stakeholders not to adhere to existing legislation. As long as law enforcement is not improved at higher level decisionmaking (provincial and national government), and rule-breaking organizations (including government organizations such as some of the municipalities) are not held accountable, attempted sanctioning through the initiatives will have limited effect. If initiatives are unable to create particular pressure on rule breaking actors to change their practices then it is vital that higher level authorities step in.

Principle 6: Conflict resolution mechanisms

The organizations that participate in the initiatives bring varying perspectives, interests and values into the interactions. For example, organizations that have partnered to pool resources for alien clearing may still be motivated by differing interests such as creating jobs through public work programs (WfW), protecting natural habitat and biodiversity (WWF) or increasing the water supply for agricultural production (IBs). Finding ways to deal constructively with emerging conflicts of interests and disputes is vital to the success of the collaborative efforts (Dietz et al., 2003). Participatory and democratic processes within the initiatives can create low-cost conflict resolution mechanisms. Yet, leadership and the possibility to turn to higher level conflict resolution mechanisms are also required.

Initiative based

The initiatives show that it is critical that all actors are viewed as equal partners and that leadership must be unbiased. Both conditions were missing in the in the WQ task team and, at a later stage, in the Adopt-a-River Stellenbosch initiative. The initiatives that reveal high levels of collaboration (e.g., BEMF and Lower Berg initiative) have well-functioning conflict resolution mechanisms which are primarily based on deliberation.

Catchment wide

Easily-accessible conflict resolution mechanisms at catchment scale do not really exist. One problem is that the DWA does not act as a facilitator. This became clear when discussing the disputes that arose between the government departments in relation to the water quality task team. The DWA currently takes the position of an affected party that needs to defend its interests and rights. Furthermore, it became also clear in the investigations into the initiatives that many disputes are

related to the cost of carrying out management functions. These disputes must be addressed at the catchment scale or even at higher levels of decision making.

Principle 7: Minimal recognition of rights to organize

The findings in this study support the argument that Principle 7 has particular importance in heavily regulated policy fields, i.e., in situations where traditional governance structures with established specific patterns of interactions and decision-making procedures prevail (Termeer et al., 2013). The Berg catchment certainly reflects such a situation. The recognition of rights, especially from higher level authorities, renders possible the required 'external' legitimacy which enables the collective action initiatives to develop and implement specific management actions to influence higher-level policy making and to claim financial and technical support. In this way, the recognition of rights also positively affects the capacity to self-organize. Hence, the development of enforceable joint rules is not only dependent on 'internal' legitimacy but also on 'external' legitimacy (Provan and Kenis, 2007; Jentoft, 2000).[123] Other studies have come to similar conclusions (see for example Sandström et al., 2013; Suskevics, 2012)

Initiative based

The relationship between the recognition of rights and the capacity for successful collective action is well illustrated by the example of the BEMF initiative. While the BEMF has developed into a very effective collective action initiative based on trust and reciprocity, its sustainability as well as effectiveness remains fragile. The BEMF has not been acknowledged as a legitimate player by several higher level decision makers in the catchment. This is exemplified by the lack of financial support and the marginalization of the forum from decision-making processes relating to the management of the Berg River. As a consequence, knowledge generation and institutionalization of the initiative are encumbered.

Similarly, observations could be made of the 24 River initiative and the Lower Berg initiative. Both initiatives represent hybrid governance mechanisms whose role has until now not been sufficiently recognized by more traditional government structures. Without the required acknowledgment they will struggle to access important information and are unlikely to become well integrated into the larger Berg River management system. Interestingly, the WQ task team and the Adopt a River

[123]Internal legitimacy relates to the acceptance and credibility that that those involved in the initiatives give to the decision-making processes. "External" legitimacy refers here to the acceptance by actors outside the management system (Jentoft, 2000). That is, goals of the particular management system need to be consistent with the beliefs of actors external to the specific system (Lundmark et al., 2014).

Stellenbosch have the necessary authority and 'external' legitimacy but these initiatives lack 'internal' legitimacy (i.e. organizations that are participating in the initiative or are affected by their rules do not view the decision making within these platforms as fair or credible.)

Catchment wide

Ostrom et al. (1999) point that higher level government can either facilitate or hinder self-organization at the local level. The authors (1999:281) continue to say that "[n]ational governments can […] hinder local self-organization by […] maintaining that the state has ultimate control over resources without actually monitoring and enforcing existing regulations." To a large extent this seems to be still the case in the Berg catchment where the DWA still insists on its ultimate control over the water resources without respecting and legitimizing ongoing effort of self-organization and local management and without actually addressing the issue adequately.

Principle 8: Nested enterprises

The findings from the investigation of the collective action initiatives suggest that nested enterprises seem to be of great significance for the performance of the specific initiatives. To obtain legitimacy and support the collective action, initiatives are required to cooperate and link to other existing formal decision-making processes within and beyond the operational level of the catchment. Only then is the necessary space for self-governance and for establishing robust long term collective action provided (Termeer et al., 2013; Wynborn and Bixler 2013).

Initiative based

The quantitative and qualitative analyses suggest that the IB initiative is the only initiative which is well embedded in the Berg management network. The SNA in Chapter 5 illustrated how the initiative, through its strategic linkages, can influence others operative in the Berg catchment as well as higher level decision-making processes. Furthermore, the IB initiative itself represents a system of nested enterprises. Hence, the individual IBs are embedded in the Main IB but they also have some autonomy to develop their own rules and activities within their specific jurisdiction. The organizational structure of the initiative and its strategic linkages ensure that the IB initiative is well-informed about new developments, opportunities and issues concerning the management of the Berg catchment. This has strengthened the capacity of the group of IBs to self-organize and to prioritize its collective action activities. All other initiatives lack this embeddedness. Consequently, the costs of acquiring important information and for accessing support structures as well as decision-making processes are much higher for the other initiatives.

An interesting observation could be made for the BEMF. As mentioned earlier, the BEMF is well embedded in the Berg management network. However, the BEMF is also nested in the coastal governance system. Representatives from the BEMF are, for example, participating in the Municipal Coastal Committee (MCC) and the Provincial Coastal Committee (PCC). This makes it possible to escalate estuarine/coastal issues from the estuary forum to the MCC, the PCC or to the National Coastal Committee. Hence, the BEMF has been able to learn from the lessons of other estuary forums and has also access to some resources and conflict resolution mechanisms from higher level coastal management platforms.

Catchment wide

While the potential that the individual initiatives hold for enhancing horizontal cooperation among the organizations should be recognized, it is also important to realize that individually the initiatives will not be able to effectively address the two management issues . Both issues are of such a complex nature that they require actions at several levels and the involvement of various modes of governance. Hence, nested enterprises are a necessary condition for enabling AM in the Berg catchment. Most of the initiatives are not well embedded in higher level decision-making processes concerning the catchment and the two management issues (see Table 6-1). However, nesting does not only refer to vertical embeddedness but also horizontal nestedness. The findings from the workshops as well as the SNA show that the individual initiatives are not well connected to each other. The horizontal nestedness that is currently missing from the Berg management network is critical for complementary monitoring activities, for understanding upstream-downstream relations and the spatial effects of management changes at one locality.

6.3.1. Summarizing key constraints to collective action

The employment of Ostrom's eight design principles provided knowledge about the nature and extent of horizontal cooperation in the Berg catchment that could not have alone been gained through the SNA as presented in Chapter 5. The analysis brought to the fore key constraints that inhibit social cooperation and brought into view larger governance arrangements (beyond the Berg management network) that significantly affect the success and sustainability of the initiatives and the self-organizing efforts in the catchment.

The identified constraints can be broadly summarized as follows:

- The negative impact of the national water governance system which is currently characterized by institutional and organizational uncertainty;

- The lack of access to adequate and relevant, catchment-wide information on the ecological status and socio-economic trends in the Berg catchment, which is to a large extent the result of a missing monitoring system and communication strategy;
- The missing support and legitimacy from higher level governmental authorities, in particular in terms of law enforcement, conflict resolution mechanisms and incentive structures;
- The limited ability to affect rules and decision-making processes that go beyond the internal affairs of the initiatives;
- The inadequate resources provided to the organizations to fulfill management functions and to afford the transaction costs necessary for iterative learning and collaboration;
- The limited space and time provided for learning and deliberation and therefore knowledge generation within and across the initiatives; and
- The persistence of rigid boundaries rather than carefully defined actor and resource boundaries (alien clearing vs water quality management, water service management vs. water resource management).

6.3.2. Reflecting on the robustness of governance: the extent of AM and polycentric governance in the Berg catchment

In Chapter 3 it was argued that Ostrom's design principles create a critical linkage between AM and polycentric governance. That is, jointly, the design principles allow for the assessment of the extent of AM and of polycentric governance in the governance arrangements through which the Berg catchment is managed, which in turn speaks to the robustness of the existing governance. Robust governance has been defined in this thesis as arrangements that can sustain key management functions and address management challenges in light of socio-economic and ecological changes. It was argued that governance arrangements that contain features of AM and polycentric governance are more robust because they create the conditions under which effective governance can be sustained.

Section 3.2.3 and Figure 3-7 highlighted that design principles 1, 2 and 3 are critical for establishing important conditions for collaboration. Principles 4, 5, and 6, on the other hand, provide opportunities for learning and knowledge generation about the SES. Finally, Principles 7 and 8 facilitate cross-boundary linkages which allow for the development of effective multi-level governance arrangement.

The detailed discussion of design principles 1 to 6 provides testimony that the existing arrangements through which the Berg catchment is governed afford few possibilities for learning and collaboration. It is therefore not surprising that AM remains an abstract concept rather than a well-integrated practice in the catchment. At first glance this may provide a bleak picture for realizing the sustainable management of the Berg catchment through joint action. However, the analysis also demonstrated that some of the examined initiatives have considerable potential to become effective governance arrangements at the sub-catchment level (see Table 6-2). Some of them already fulfill two important governance functions: the strengthening of collaborative relations among some organizations and the partial uptake of some of the management functions. The investigation showed that, in particular, those initiatives with engaged leadership and that have developed a culture of deliberation, actively integrating the knowledge that the various organizations bring into the initiatives, have been able to create a common and more holistic understanding of the catchment or specific issue areas (examples are the BEMF, the 24 River initiative and the Lower Berg initiative and to a lesser extent the IB initiative). For some initiatives, learning processes and knowledge production were enhanced through specific monitoring activities (e.g., the BEMF, the Lower Berg Initiative and the IB initiative).

In the case of the Berg catchment, it appears that the greatest obstacle to robust governance relates to the conditions created by the arrangements that go beyond the individual initiatives and the catchment. Hence, the weak performance related to design principles 7 and 8 suggest that a functioning polycentric governance system does not exist and that vital cross-boundary linkages that foster vertical integration have not been established. Therefore, it does not come as much of a surprise that the current arrangements that govern the Berg catchment do not score highly when it comes to the maintenance of key water management functions, the efficient response to water management problems and the equitable and accountable distribution of cost and benefits.

6.4. Additional factors shaping collective action

Organizing the initiatives according to the themes proposed in Chapter 3 (Section 3.2.4) turned out to be not particularly helpful for highlighting the additional factors that inhibit or foster collective action in the Berg catchment. However, they were helpful in capturing and understanding the role of agency. It became evident that agency in the form of champions and leadership had a significant influence on the quality and sustainability of the collaborative efforts. In reflecting further on the interpretations of the analysis, the following conclusions can be drawn:

6.4.1. Agency: the role of champions and leadership

All of the initiatives did in some way experience significant organizational and resource specific constraints. Yet, several representatives from different organizations found ways of interpreting their organizational mandates in such a way that organizational and external obstacles could be overcome

and issues could be addressed collectively (e.g., accessing funding for alien clearing in the BEMF, the WCDM and the Department of Agriculture, Western Cape). For example, the representative from the Department of Agriculture, Western Cape framed the issue of invasive vegetation as a disaster management issue. This enabled him to access more funding for his organization and to engage other provincial government departments responsible for disaster management.

Individuals such as the representative from the Department of Agriculture, Western Cape display high levels of commitment and the will to contribute to the sustainable management of the catchment. Champions like him are important for getting the buy-in of the organization they represent and for convincing other organizations that joint actions are a good strategy for achieving organizational objectives. To develop this type of agency, it is essential that the participants of the initiatives are knowledgeable, i.e., have access to relevant information, and can influence decision-making processes that affect their activities. During the fieldwork, it became evident on several occasions that champions are critical for overcoming legislative and bureaucratic obstacles and for moving the initiatives forward. Organizations that had internal expertise relating to environmental governance or water resources management were often those from which champions emerged. Yet, it also became clear during the fieldwork that the agency of such champions can remain highly restricted. Returning to the example of the Department of Agriculture, Western Cape representative, while he was able to create more awareness, his limited formal influence within larger decision-making processes and formal authority on the subject prevented him from taking a catchment-wide leadership position.

Leaders, as understood in this thesis, may be distinct from champions in that they have the legitimacy and means to transform innovative ideas into action. Reflecting on the level of cooperation within the collective action initiatives, it appears that leadership is important for coordinating internal affairs and in negotiating trade-offs that may arise from a conflict of interests. The findings further highlight that it is not enough to have a central actor who may have the authority to coordinate action but that the leadership must be unbiased. In other words, leaders must have an interest in advancing the objectives of the initiative and not act solely in the interest of the organization that they represent. This type of leadership is particularly critical for externally initiated collective action (WQ task team, Adopt-a-River Stellenbosch, BEMF). Externally initiated collective action represents situations where trust relations are still fragile and organizations may be constrained by a lack of resources or rigid mandates. Leadership can provide for the necessary vision and ensure that the initiative does not get overwhelmed by the magnitude of the problem. An impediment to the Adopt-a-River Stellenbosch initiative was, for example, the loss of leadership caused by the resignation of an employee. Without a clear vision and pragmatic leadership, activities

turned into ad hoc efforts without seeking the necessary integration. From the findings it also appears that catchment-wide collective action requires leadership at the scale of the catchment. This should not just be exercised through a top-down intervention. Rather, it should be accommodated by nested leadership as has been described by Termeer et al. (2013). Hence, leaders at different levels need to form a collaborative network through which they can form institutional arrangements that allow them to regularly exchange information and to coordinate action.

7. Chapter: Discussion & Conclusion

This concluding chapter presents a synthesis of the key findings of this research. First, the findings and conclusions of the two empirical chapters (Chapter 5 and 6) are summarized. They are interpreted in relation to water governance in South Africa and the management of regional SESs. Reflecting on the insights that were generated, the research question *When does horizontal cooperation contribute to adaptive management in complex governance arrangements?* is answered. Following that, key contributions that the thesis has made to knowledge are summarized. The subsequent section discusses the applicability and relevance of a relational approach for providing new insights on the intersection of horizontal cooperation and complex governance arrangements. Here, the usefulness of the conceptual design and the proposed analytical framework are discussed. In light of the understanding gained during the research process, the specific limitations of the framework and the methods employed are pointed out. The chapter closes by providing an outlook on future research directions.

7.1. Key findings in the context of water governance in South Africa

Water management in the Berg catchment has changed significantly over the past decade. The role of local organizations has gained prominence in addressing existing issues related to the Berg River and in contributing to day-to-day management activities. In addition, several inter-organizational platforms have become potent actors in water management at the catchment scale. The participation of the large number of non-mandated organizations (43%) is indicative of the changed composition at the operational level (see Chapter 5, section 5.2). It appears though, that the willingness to take action is not so much induced by South Africa's progressive water legislation, which strongly promotes greater stakeholder participation. For many organizations, their involvement in water management is mainly motivated by the perception that the state (in this instance the DWA) is not able to maintain a functioning management system and to effectively address the issue of water quality. While this driver is a potent catalyst for changing the stakeholders perceptions that water management is not solely the responsibility of the DWA, stronger incentives (e.g. secure property rights, local benefits and access to higher level decision-making) and support structures are necessary, so that stakeholders contribute to management activities on a regular basis and in ways that go beyond their immediate interests.

Involving more actors at the operational level, even when they are from different administrative levels and are representing different stakeholder groups, does not automatically lead to effective and sustainable management. The examination of water management in the Berg catchment clearly shows its limited effectiveness. The insufficient execution of management functions in the Berg

catchment can partially be explained by the lack of cooperation among the core WMOs, i.e., those that have a formal mandate. Evidence of the limited information exchange and prioritization of activities among the core WMOs was provided through the quantitative assessment of horizontal cooperation in Chapter 5. These limitations have negative implications for the execution of management functions, as well as for creating and promoting a vision for the catchment. Although various collaborative efforts to address the two management issues, degrading water quality and alien-invasive vegetation, among the stakeholders in the Berg catchment exist, the lack of horizontal cooperation among core WMOs has significantly impeded the self-organizing efforts of other organizations in terms of informed decision-making, prioritization and up-scaling.

In the case of the Berg catchment it appears that it is not simply the lack of interactions among the organizations involved that explains the poor management of the Berg River. The findings from the examination of stakeholder relations revealed that the quality of interactions also hampers the utilization of the expertise and the substantial efforts that exist in the Berg catchment. Lots of recycled and outdated information gets circulated even among those organizations that are well connected in the network. Chapter 5 highlighted that this is partially a result of the limited access to catchment-wide scientific ecological knowledge and limited integration of knowledge generated at sub-catchment level (e.g., within the collective action initiatives). Without better knowledge on the status of the catchment, including trends and developments, a better integration of major water users, and an inclusive vision for the catchment, developing collaborative relations through which management issues and functions can jointly be addressed remains limited.

While more financial resources could assist in capacitating the core WMOs in carrying out key management functions, this is not sufficient for achieving AM in the catchment. The study shows that key deficiencies are of a relational nature: narrowly defined boundaries (such as the distinction between water services and water resources management or water quality and alien-invasive vegetation), limited trust, and a restrictive organizational mandate. The institutionalization of horizontal linkages (e.g., through the establishment platforms for joint learning and planned coordination) could greatly assist in building trust and a shared vision of and feeling for joint responsibility for the catchment.[124]

[124] A potential candidate for such a platform is a program called the Berg River Improvement Plan which was established in 2013 under the leadership of the provincial government. The WQ task team, discussed at great length in this study, was also revitalized after the completion of the fieldwork for this study. The core WMOs are members of both initiatives. In order to strengthen effective water management, these initiatives should make it their mandate to assist in creating functional linkages between the core WMOs and in fostering expertise within the core WMOs through knowledge sharing.

One of the major impediments to the development of trust and reciprocity among stakeholders in the catchment seems to be the institutional uncertainty that has dominated the national water governance system for several years (i.e., issues regarding the establishment of CMAs, role and composition of WUAs, and water and land reform). In Chapter 6 it became evident that because of this uncertainty, roles, responsibilities and boundaries of the various organizations, involved in the management of the catchment, remain vague, and organizations find it difficult to agree on how costs and responsibilities should be shared.

The observed institutional uncertainty needs to be discussed in the context of the transformation processes taking place in South Africa's water governance system, i.e., the fact that the establishment of new institutional arrangements and reconfiguring actor relations are not only taking place in the Berg catchment. The transformation of the water governance system has been primarily the responsibility of the DWA and the difficulty of the task should not be underestimated. Making governance more inclusive and adaptive is particularly challenging in a country where access to decision-making processes and participation in water management has been extremely unequal (Goldin, 2010; King and Piennar, 2011). The DWA neither has the capacities nor the means to lead the transformation processes and the management of South Africa's catchment areas through a mere top-down approach. The fact that water is a cross-sectoral domain implies, furthermore, that there will always be other powerful actors (e.g., other national government departments and private sector actors) that will contest the authority of the DWA in specific decision-making processes.

Notwithstanding that the examination of the Berg catchment only provides a glimpse into the working of South Africa's water governance system, the findings illustrate that the current steering of activities by the DWA has been rather counterproductive. This has been also echoed by other studies such as (Colvin et al., 2014). The DWA has been interacting in the catchment either through non-involvement, which could be observed particularly at sub-catchment level, or through non-inclusive top-down approaches at catchment and national level. The findings further suggest that the DWA finds it challenging to move from the more familiar top-down engagement to collaborative, non-hierarchical interactions. Mindful that the organization has been significantly constrained in its ability to coordinate activities because of insufficient human resources with respect to particular technical skills (King and Piennar, 2011; Schreiner and Hassan, 2010), it appears the DWA has completely overlooked the need for and importance of transforming itself into a learning organization. That is, without the DWA adopting a learning approach that entails reflection within its own organizational structures, the organization will fall short of its intention to transform South Africa's water governance system. To fulfill its leadership role, the DWA needs to acquire skills for coordinating actions through collaborative, non-hierarchical interactions. This can be achieved through a genuine

and systematic engagement with learning and management processes at different levels. In order to make use of the learning processes and incorporate them into its decision-making processes and its organizational strategies, it is also critical that the DWA foster and encourage learning processes and information within itself. Although the interactions between the DWA regional and the DWA national offices were not the focus of this study, the lack of communication and learning within the DWA and its negative effects on the interactions within the Berg catchment became obvious.

The findings from this study highlight strongly the need for catchment-wide coordination. While some management functions can be carried out at sub-catchment level, many require that they are coordinated at catchment scale or even higher. CMAs could make valuable contributions in this regard as they provide the organizational space for cross-sector integration and cooperation (Dent, 2010 and 2008). The role of such organizations is less about taking over all management functions concerning the water resources of a catchment and more about assisting in creating a common vision, aligning collaborative efforts, and strengthening self-organization at the sub-catchment level. In light of a recent decision by the DWA that two to three adjacent catchment areas will be coordinated by one CMA[125], it is unlikely that a CMA can employ the same strategy for coordinating management in the different areas under its jurisdiction. CMAs will be most successful if they facilitate management through a better understanding of the collaborative efforts that already exist, strengthening them and where necessary trying to link them.

That said, it needs to be highlighted that CMAs can not be seen as the panacea for South Africa's water governance challenges. The observations made in this and other studies (e.g., Ernstson et al., 2008) clearly show that creating and maintaining relations comes at a significant cost. Furthermore, given that water is a cross-sectoral issue, many management challenges have their origin outside the catchment and the water governance system. Hence, the coordinating role that CMAs can fulfill will have its limits. It is therefore important that CMAs are supported by other actors and initiatives that are in a position to take up such a bridging role, especially with regard to higher level decision making. For example, the Strategic Water Partners Network – South Africa (SWPN) is a public-private expert leadership group, formed in 2011 and chaired by the Director-General of the DWA. It is intended to strengthen South Africa's water security through collaborative private-public projects that can strategically address South Africa's persistent water management challenges (e.g., the

[125] Instead of having 19 CMAs for 19 catchment areas, it was recently decided by the DWA to establish 9 CMAs that will be responsible for the 19 catchment areas. (Schreiner and Hassan, 2010)

malfunctioning of municipal sewage treatment plants) (NEPAD, 2012).[126] Hence, SWPN builds horizontal cooperation at the highest level of decision making in South Africa. To contribute effectively to water management, it will be vital that this high level partnership becomes well connected to the catchment areas so that it can provide tailored incentives and supports structures that enhance the management capacities and collective efforts at catchment and sub-catchment scale. Hence the better the SWPN is able to strengthen local scale governance arrangements the more likely it will be able to accomplish the governance objectives it has set out to accomplish. Other studies, such as Bixler (2014), are in strong support of this argument.

Key messages-South Africa's water governance system

- More stakeholders can participate in water management, yet options generation as well as the meaningful engagement of marginalized and not well organized groups remain low.
- Opportunities created through self-organization and collective action at sub-catchment level are not well utilized.
- Institutional uncertainty is a major reason that horizontal cooperation in the Berg catchment is not conducive to AM and for the effective co-production of public benefits.
- To a large extent this institutional uncertainty has been created by the DWA which until now has failed to transform itself into a learning organization.
- Learning, through the integration of technical and ecological knowledge, appears to be most important for changing actor relations and perceptions on water security.
- Capacitated core WMOS are critical for the fulfillment of key management function and for the utilization of the self organization of other actors.
- Core WMOs will only be able to fulfill management functions if they cooperate with each other and take advantage of the contributions of other actors.
- CMAs and other coordinating forums (above and below the catchment scale) are critical for establishing vital vertical and horizontal linkages and for creating effective incentive structures.

7.2. Key findings in the context of management of regional SESs

The expansion of the operational level is a development that the Berg catchment shares with many other regional SESs (e.g., e.g. Bixler, 2014, Marshal, 2009; Berkes 2007; Armitage et al., 2008b). At

[126] Among the partners are South African Breweries, Coca-Cola, Anglo American, Sasol, Nestlé, Eskom, WWF and SALGA and the 2030 Water Resources Group.

best, the participation of more actors leads to an effective execution of management functions, because necessary resources and actions can speedily be deployed at the most appropriate levels or scales. The findings from the Berg catchment also suggest increased fluctuation at the operational level. That is, it may change in size depending on the management issue or function to be addressed. Yet, if a joint vision for and common knowledge base of the SES is not actively built and shared among a diverse set of actors, the expansion of the operational level will simply lead to fragmentation and may even result in more unresolved conflicts of interests and management gaps. Hence, actors will continue to advance narrowly-defined self-interests which make it extremely difficult to create functioning governance arrangements among semi-autonomous actors .

This study clearly supports the argument that collective action and self-organization are important for the effective management of regional SESs (e.g., Bixler 2014; Wynborn 2014; Pollard, and du Toit, 2011; Cundill and Fabricus, 2010; Knüppe and Pahl-Wostl,2014). Yet, the findings from this case study also suggest that self-organization within actor networks that manage regional SESs on their own will rarely lead to AM and robust governance arrangements. This is particularly true in regional SESs that are characterized by great power discrepancies and competing user interests. The observations made in this study show that it is primarily well-resourced and well-connected organizations that are able to advance their interests and viewpoints.

An important point that until now has not received adequate attention from the SES literature is the relationship between modes of governance and AM in regional SESs. Using a relational approach, this thesis demonstrates 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. Chapters 5 and 6 jointly demonstrated that, 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 also influenced by other institutional and organizational structures in which the actors are embedded. Unexpectedly, market mode incentives have stimulated collective action in the Berg catchment and accentuated the need for addressing degrading water quality. Informal relations and emerging processes such as the creation of inter-organizational platforms (such as the BEMF) matter for learning and for providing opportunities for collective action. Yet, the incentives (or lack thereof) created through the hierarchical steering of the South African water governance system by the DWA have been rather counterproductive. That is, so far the self-organizing efforts at sub-catchment level could not be transformed into functioning governance arrangements because of the constraints that are imposed by the hierarchical mode (i.e., limited nestedness and institutional uncertainty). This illustrates the importance of understanding

the nature of the effect of each mode of governance on the overall performance of the actor network and how processes related to a specific mode affect the incentives for horizontal cooperation in other modes. Only then can informed decisions be made on where and how to intervene in order to establish robust governance arrangements and to utilize existing opportunities that promote sustainable management practices.

The importance of iterative social learning processes for arriving at a common understanding and for fostering mutual interests and needs has been frequently emphasized in the SES literature (e.g., Berkes, 2009). However, the investigation in the Berg catchment demonstrated that collective learning processes in regional SESs necessitate the integration of legitimate technical and ecological knowledge. Such knowledge is not only a critical requirement for making informed decisions that lead to sustainable management practices, but it can also become a common point of reference upon which trusting relations can be built among actors whose previous forms of engagement were marked by adversary and distrust.

It has been argued in Chapter 1 that the limited transition toward AM practices can only be understood if the rising complexity of governance arrangements is taken into consideration. In particular, the findings derived from investigating the collective action initiatives in Chapter 6 highlight that it is not so much the complexity of arrangements that is the problem. Complex governance arrangements are often desirable as they lead to the institutional diversity necessary for the effective management of SESs and for motivating a diverse set of actors to contribute to the fulfillment of management functions. This finding is consistent with those of scholars such as Elinor Ostrom who have argued that to be effective, governance systems must match the complexity of the SES (Ostrom, 1990, 2005, 2009b; Crona et al., 2011; Andersson et al., 2014). It is critical to understand the distribution of power and influence, the interplay of modes of governance, and the prevalence of collaborative structures, and how these in turn affects learning and collaboration at the operational level. The examination of the Berg catchment also highlighted that the cost-benefit distribution for the management of the SES needs to be assessed in a holistic manner. What are the costs for carrying out management functions and how does this relate to the capacities and benefits of the specific actors? How does this cost-benefit distribution relate to organizational mandates and the water governance system as envisioned by legislation? Gaining such understanding necessitates knowledge on the actors that form part of the operational level and the ways in which they contribute to the management of the SES.

Key messages-management of regional SES

- In regional SESs the operational level has increased and become more fluctuating making day to day management functions more challenging to fulfill as the necessary cohesion among the actors is not easily achieved.
- Self-organization and collective action that arise from horizontal cooperation are important for AM in regional SESs.
- Self-organization in regional SESs requires institutional stability and nestedness.
- Collective learning processes in regional SESs necessitate access to technical and ecological knowledge.
- Complex governance arrangements are not a hindrance to robust governance.
- Modes of governance intersect at the operational level and consequently influence the nature of horizontal cooperation.

7.3. Horizontal cooperation as means for achieving adaptive management

This research set out to provide clarity on the concept of horizontal cooperation. This was done by proposing a workable definition which emphasized collaborative, non-hierarchical interactions of actors across sectors, modes of governance and spatial scales, and by investigating these characteristics through a relational approach. The empirical investigation into the Berg catchment confirmed that these characteristics do indeed capture horizontal cooperation in complex governance arrangements.

The key message to take from this study is that horizontal cooperation does not by default become a means for adaptive management. In regional SESs characterized by complex governance arrangements, horizontal cooperation is not easily achieved. 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. The study confirms that self-organization and collective action that arise from horizontal cooperation are important for the AM of regional SESs. However, without being supported by larger structures and decision-making processes, they are insufficient for creating and sustaining robust governance arrangements. With respect to the Berg catchment, it became evident that horizontal

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

This thesis has made valuable contributions to a growing field of interdisciplinary research on SESs. In recent years, the interest in the concept of SES has been rising (see e.g., Halliday and Glasser, 2011). However, it has become evident that more studies are required to unpack relational patterns, governance and environmental outcomes in such systems (Young et al., 2006; Janssen et al., 2007; Bodin et al., 2011). By provided more clarity on the concept of horizontal cooperation as well as by developing a systematic framework through which horizontal cooperation can be assessed, this thesis provides valuable insights into the research question *When does horizontal cooperation contribute to adaptive management in complex governance arrangements?* Hence, while this thesis is only able to answer the question for a specific SES (i.e., for the Berg catchment), the proposed framework makes it possible to test and validate the findings in other regional SESs.

7.4. Critical reflections

7.4.1. The contribution of a relational approach for providing new insights into horizontal cooperation

The relational approach advanced in this thesis focused on actor networks and collective action. More specifically, actor relations among a group of organizations that jointly manage a particular regional SES served as a starting point for the investigation into horizontal cooperation. The quantitative assessment of the patterns of interactions, achieved through a formal SNA, gave valuable insights into how these interactions have shaped learning processes and collaboration among the organizations. These quantitative investigations were supplemented by a qualitative analysis of collective action. This in turn provided a comprehensive understanding of how the nature of, and constraints to, horizontal cooperation in regional SESs can be assessed.

A key advantage of the relational approach has been its ability to delineate complex governance arrangements, i.e., the methodological tools that have been employed in this study allow the identification and description of actor constellations and institutional processes that characterize specific arrangements. That is, while the unit of analysis has been an actor network, the focus on the patterns of interaction brought revealed how designed and self-organizing components and processes are organized in specific governance arrangements. This in turn helped in the understanding of how they individually, but also jointly, built upon, facilitate or obstruct horizontal cooperation. In other words, the relational approach helped to clarify which components (actor

constellations and institutions) matter the most in a particular governance setting, the relationship among those components, and the governance outcomes of their interactions.

While the approach was clearly able to detect and describe in great detail the operational level and the complexity of governance arrangements therein, it fell short in revealing the entire multi-level governance system that shapes water governance in South Africa. For example, it became quite clear during the research that vertical linkages (in particular vertical nestedness) plays an important role in horizontal cooperation. Furthermore, observations on the effect of existing institutions (in this case formal rules) on horizontal cooperation through an investigation of actor relations only has limited explanatory power. Another shortcoming of the approach has been its limited ability to capture those organizations holistically that have a national, regional but also local presence. More specifically, while the study provided a thorough examination of inter-organizational relations, it could not do so for intra-organizational relations.

The advantage of using a polycentric governance lens for examining complex governance arrangements is that it enables the creation of a more holistic understanding of the components and processes that characterize these arrangements. By taking into consideration the nature of existing institutional and actor diversity, a polycentric governance lens assists in the evaluation of the functioning of these processes and components, and the constraints upon them. Furthermore, this increases the researchers' ability to understand how the interplay of the different governance modes affects collaboration among semi-autonomous actors. This understanding is especially important for maximizing institutional diversity to foster an effective governance system that builds upon learning and collaboration. The case of the Berg catchment illustrated that the decentralization that has taken place in South Africa's water governance system has not been faithful to the polycentric idea. Whereas lower level decision-making centers like municipalities and IBs have been given greater responsibilities in the management of the catchment, this has been done without nesting them into higher level structures. This lack of vertical integration overwhelms the operational level making it difficult to co-produce services for public benefit.

7.4.2. Reflection on the analytical framework

The formal SNA employed in this study revealed how the composition and structure of the Berg management network has shaped learning processes and collective action and given rise to specific management practices. A key advantage of the SNA has been that issues concerning the management of SES could be re-framed in network terms, demonstrating how the nature of interactions affects management. More specifically, the SNA helped to operationalize and empirically measure concepts that are otherwise abstract and difficult to express. Furthermore, the visual

representation of complex relational structures affecting learning and collaboration in the Berg catchment turned out to be an analytically valuable descriptive tool.

The examination of the two network characteristics, heterogeneity and cohesion, created a better understanding of why management performance is poor despite the diversity of actors, resources and knowledge. It became apparent that the mobilization of resources and the coordination of collective action are constrained by the catchment-wide lack of cohesion in the network. The quantitative analyses also provide plausible explanations of why specific actors like the IBs have been able to advance their interests in the network and why others, such as municipalities in the lower catchment, failed to do so. Furthermore, the SNA helped to better understand how formal authority relates to influence in the catchment and in the management practices. For example, the DWA, because of its formal authority, continues to have significant influence in the decision-making processes of the network even though the organization is currently not able to fulfill its leadership role. Other actors that have engaged more pro-actively in collaborative efforts at the sub-catchment scale are limited in their bridging role because they lack the formal authority.

Cohesion and heterogeneity were useful indicators in the assessment of horizontal cooperation. The complementary measurements for each characteristic allowed for meaningful interpretations. For example, looking at the overall connectedness among the organizations participating in the management of the catchment was not very informative on its own. A better understanding was available after investigating the cohesion among the core WMOs and after having identified the collaborative clusters that have formed within the Berg management network. Concentrating the interpretation of heterogeneity on access to ecological knowledge and network integration of major users and highly dependent stakeholders demonstrated that the high actor diversity that is present in the network is not well utilized. The investigation of the two network characteristics also illustrated why learning about the catchment is very restricted and why some actors continue to remain under the false impression that their water security is not dependent on the catchment. Together, that leads to the conclusion that the existing horizontal cooperation is not conducive to AM and that consequently the realized adaptive capacity is low in the Berg catchment. The analyses also highlighted the integrated relationship between the two network characteristics and that in order to serve as indicators for horizontal cooperation they need to be discussed jointly. Notwithstanding that the simplification of complex processes through the SNA helped in their understanding, rich qualitative information was lost in the quantitative analyses. The use of qualitative information generated through semi-structured interviews, participant observations and focus groups proved to be highly beneficial for addressing the deficiencies of the quantitative SNA.

The investigation into the collective action initiatives in Chapter 6 made use of and built upon this rich qualitative information.

Reflecting on the SNA design and execution, it needs to be said that while the whole network approach was helpful for describing the relations and behaviour among the actors operative in the Berg catchment, an ego network analysis would have been more appropriate for gaining a better understanding of the extent to which these actors are linked to other levels of decision making. Time and resource constraints did not allow for the undertaking of this complementary measure. Furthermore, in this thesis relations were captured only at one point in time. A longitudinal study may have better captured changes in the network and allowed for plausible explanations as to which factors or actors triggered theses changes. As well, it needs to be mentioned that the SNA, because it captures stable and regular interactions, has not been very sensitive in detecting newly established initiatives and processes. For example, the Berg River Improvement Plan and the larger SWPN had little maturity at the time when the field work was conducted. Hence, both could not be detected in the Berg management network even though they already had started their efforts to strengthen water management.

Perhaps the most valuable insight for the assessment of horizontal cooperation to take from the employment of Ostrom's eight design principles is that they were able to demonstrate how critical vertical integration in the form of nestedness is for collective action and the capacity to self-organize in regional SESs. The study confirms the conclusion of others (e.g., Termeer et al., 2013; Ariras et al., 2013; Huntjens et al., 2012) that the design principles are of great relevance for the investigation into regional SESs and their management. Chapter 6 provided clear evidence that in regional SESs, horizontal cooperation builds on trust and reciprocity. As demonstrated in this study, the design principles were valuable in understanding the robustness and effectiveness of individual collective action initiatives as well as the larger arrangements arising from horizontal cooperation. However, they were less useful in capturing and examining the linkages between the collective action initiatives. This may relate to a specific weakness which needs further exploration. That is, it appears that Principle 8 (nestedness) is the least developed and empirically investigated principle in Ostrom's work. However, in relation to regional SESs and their complex governance arrangements, design principle 8 seems to be most critical. Furthermore, while accounting for vertical nestedness, Ostrom's framework does not explicitly account for and point to the role of horizontal nestedness. Hence, more research is needed to advance the understanding of the processes and conditions that relate to design principle 8.

7.4.3. Outlook with respect to future research

Through both the findings and the reflection on the conceptual and analytical framework, new and interesting questions have emerged. The ones that seem critical in advancing the understanding of horizontal cooperation are summarized below:

There is a clear need to investigate further the relationship between horizontal cooperation and vertical integration. As mentioned above, one option could be to undertake an ego network analysis to explore the extent to which members of different collaborative actor networks that operate at different levels, but who have similar governance objectives (e.g., water security), are linked. To what extent do these linkages indeed foster learning and collaboration across and within those networks? Which organizations can function as bridging organizations and span the different levels of decision making? What would be a meaningful definition for vertical integration that can capture integration within and across the three ideal governance modes? These and similar questions can be explored using a relational approach.

The investigations into the Berg catchment show that the intersection of the governance modes do affect self-organization and collective action in regional SESs. Case studies that use the same or a similar methodological approach could provide greater insight into the role of governance modes on horizontal cooperation and AM. An interesting proposition to test would be whether coherence among governance modes (i.e., the alignment of incentives) does indeed lead to a greater willingness of organizations to take on management functions and address specific management issues.

Like other studies before (e.g., Sandström, 2011), this thesis supports the argument that an intrinsic relationship between network cohesion and heterogeneity exist. Jointly they shape collaboration and learning among interacting actors. However, the extent to which higher levels of cohesion or a higher level of heterogeneity is required in order to accomplish a specific governance outcome depends largely on the specific contextual setting and the issue at stake. When reflecting on the findings from the Berg catchment, an interesting question emerges: What is the relationship between the maturity of the governance system and the two network characteristics and how does the maturity of the governance system relate to the conditions for horizontal cooperation? South Africa's water governance system went through rapid change triggered by large scale political changes. Many relations among the various actors need to be either reconfigured or newly established. The findings from the Berg catchment further suggest that strengthening the cohesion among the core WMOs seems to be a prerequisite for the utilization of the heterogeneity that currently exists within the Berg management network. Undertaking a similar study in a country where the political systems has not seen such drastic changes and where the water governance system has changed gradually could result in more insights into the matter.

An additional research need that became apparent during the research process and that should be pursued in future studies is the following: To what extent do intra-organizational interactions affect horizontal cooperation in inter-organizational platforms and to what extent is learning generated in these platforms utilized for intra-organizational decision making? Here the literature on social learning (e.g., Sol et al., 2013) and organizational theory can provide great assistance in exploring such questions.

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Appendices

Appendix 4.1: Social Network Analysis Survey-Berg River catchment

Purpose of the study:
To create a better understanding of how issues of degrading water quality are currently addressed by the various actors in the Berg River catchment. Of particular interest to the study are the interactions and collaboration between the various actors operative in the catchment. In other words, the focus of the study is to investigate ***who is collaborating with whom on the issue of degrading water quality***. Identifying these collaborative groups will allow for a more detailed discussion of their characteristics and for possibilities to built upon the identified groups. In this context the study will explore why and how these collaborative groups have formed; what brings these actors together and motivates them to invest resources in meetings and joint action?

Please answer the following questions as a representative of your organization. I am not looking for your personal view but that of the organization that you represent.

Confidentiality
Please note that unless otherwise indicate all information provided by you and other respondents will be treated as confidential and presented anonymously. However, if applicable, I will refer to the name of the organizations that you are representing and a rough indication from which position the information was given. When presenting the data all organizations and actors will be presented as a node in the network without any reference to their names. Respondent names may be shared with my research group during the analysis of the network data.

I RESPONDENT / ORGANISATION INFORMATION

Respondent	
Name :	
Gender:	
Professional qualification	
Organisation	
Name of organization:	
Address:	
Your position in the organization:	
Years working in the organization:	

1. How would you describe the role of your organization in the Berg River catchment?

2. Please circle on the attached map which areas in the Berg River catchment your organization is active.

   2.1. What type of activities do you carry out in these areas (for example irrigated agriculture, conservation, municipal services, etc.)?

   2.2. If your activities impact the Berg River but take place **outside** the areas displayed on the map then please write down those activities and locations below.(e.g. City of Cape Town as Berg River water consumer)

Location	Type of activity

II DIRECTION OF RELATIONAL QUESTIONS

1. When looking at the recall list who do you recognize on the list as being active in the management of the Berg River. Please mark them in the blue column under the category **ACTIVE IN WATER MANAGEMENT (R1)**. Please add any organizations that you consider as important but that are not displayed on the list.

Observations:

It is clear that we can't solve the problem of degrading WQ alone but need to collaborate with others on the issue. I am therefore interested in your regular interactions with other organizations in response to the issue of degrading water quality. Please answer the following questions relating to information exchange and collaboration. But before you answer these questions let's just see what we both understand as information exchange and collaboration and in what ways the two differ

Information exchange:

- requires less resources and time, includes sharing the of information on problems or data, as well as exchanging advise

Collaboration:

- comes at higher cost, requires trust the development of common objectives and the pooling of resources , A legal mandate to cooperate does not equate in collaboration. Collaboration has often a voluntary element to it. It is often reproduced along the same relationships as this is less costly i.e. same actors will chose collaborate on different issues rather than creating new relations,
- the intention is to act collectively

Exchange of information on the status of the River (specifically its water quality)

2. From the recall list select those organizations with whom you **regularly** exchange information and advice on the issue of degrading water quality (e.g. sharing of water quality monitoring results, meteorological information, information on the environmental status of the River, capacity building, training,). Please mark the relevant organizations by selecting either the sub category **PROVIDES WQ INFO (R3a)** or **RECEIVES WQ INFO (R3b)** [the green columns]. Please add any organizations that you consider as important but that are not displayed on the list.

Observations:

3. You selected the following organizations with which you **regularly exchange information** could you please explain to me what type of information you are exchanging? Please limit your description to the three most important organizations.

Name of organization (#)	Type of info
1.	
2.	
3.	

Regular collaboration with others in the networks to address the issue

4. From the recall list select those organizations with whom you regularly collaborate on the issue of degrading water quality (joint projects e.g. monitoring activities, sharing of expertise, partnerships). Please mark them in the orange column under the category **COLLABORATIVE PARTNER (R4)**. Please add any organizations that you consider as important but are not displayed on the list.

Observations:

5. For the selected organizations can you please describe in greater detail the type of collaboration? Please specify purpose and frequency of engagement as well as types of activities. Please limit your description to the three most important organizations.

Name of organization	Describe the collaboration (including objectives)
1.	
2.	
3.	

6. Can you please explain why you collaborate on the issue of degrading water quality?

7. What have been the outcomes of these collaborations?

8. Would you say that by having your organization collaborating with others, that this has changed your organization's understanding of water quality issues and how water quality needs to be addressed? Do you for instance think that your organization has changed any priorities, or ways of working to address water quality, as a consequence of collaborations you have had with others? Can you please give me some concrete examples of this? Please remember that I am asking you as a representative of your organization and not about your individual view.

9. Would you say that your organization has learned anything new about the River and its management because of your collaborations with other organizations? Can you please give me one or two examples?

10. Which among the collaborative partners that you selected in the recall list do you think you have trustworthy relationship with? That is, which of these organizations would you trust to fulfill their obligations? Please identify them by putting a circle around the cross you used to select them. (Please remember that survey is anonymous.)

III ATTRIBUTES/ DESCRIPTION OF YOUR ORGANISATION

1. Please specify the type of organization:
   - □ Government National
   - □ Government Provincial
   - □ Government Local
   - □ IB/WUA
   - □ NGO / Association
   - □ Private Sector - Consultancy
   - □ Academic Research - Consultancy
   - □ Forum /Program/ Reference Group
   - □ Other-

specify

2. If applicable, mark your economic activities in the catchment area.
   - □ Irrigated agriculture
     Please specify
   - □ Fishing
     Please specify
   - □ Industry
     Please specify
   - □ Tourism
     Please specify
   - □ Subsistence farming
     Please specify
   - □ none

2.1. How would you rate your dependency on water from the Berg River (including tributaries)for your economic activities mentioned above? Please check one of the boxes below:

☐	☐	☐
High	partial	none

3. Through what activities are you influencing the water flow (quality and quantity) in the Berg River system?
   - □ Agricultural discharge
   - □ Agricultural abstraction
   - □ Municipal discharge
   - □ Municipal abstraction
   - □ Industrial use discharge
   - □ Industrial use abstraction
   - □ Policy
   - □ Water flow regulation
   - □ Land use change/ developments along the River bed
   - □ Other-
     specify

4. Does your organization have a specific mandate to manage water resources of the Berg River?

4.1. If yes, which aspects does your mandate cover:

- □ Discharge
- □ Abstraction
- □ Protection of wetlands
- □ Physical flow management
- □ Water quality monitoring
- □ Estuary management
- □ Alien clearing

5. Is your understanding of water quality and its impact on the River based on:
   - □ observations
   - □ anecdotal evidence,
   - □ scientific evidence (peer reviewed)
   - □ scientific evidence (not peer reviewed)
   - □ media coverage
   - □ other

     Please specify: .....

6. How frequently are you able to observe changes in the River flow (including changes in the water quality)?
   - □ Daily
   - □ Weekly
   - □ Once a month
   - □ Several times a year
   - □ never

7. What type of changes can you observe?
   - □ Physical (e.g. smell, color, changes in vegetation and animal life)
   - □ Chemical
   - □ Micro-biological

8. As I mentioned to you in the beginning water quality issues can be broadly divided into two categories, namely pollution cause by discharge (e.g. municipal and/or agricultural) and alien invasive vegetation (aquatic and terrestrial). For each of the two categories please tell me if you play an role in the management of water quality for the Berg River.
   - □ Pollution
   - □ Alien invasive vegetation

PART IV WATER RESOURCES MAMAGEMENT

1. What do you understand by the term water resource management?

2. Do you agree that water quality issues are a serious problem for the Berg River?

2.3. If you answered yes, why do you think this the case?

2.4. When and how did you become aware that water quality is a serious problem?

3. What impact has degrading water quality in the River had on the River, adjacent communities and /or ecosystems?

4. Does degrading water quality have an impact on the operation of your organization? How?

5. What have been the responses of your organization to those impacts?

6. How do you think water quality issues will affect you in the future?

7. What do you think needs to change to improve the situation?

Short-term (< 1year):

Medium-term (> year < 5years):

Long-term (> 5years):

7.1. What is your organization doing to improve the situation?

7.2. What more could your organization do within its mandate but is unable to do because of certain constrains? Please elaborate.

8. Please name three organizations that you regard as most influential with regard to water quality management at the two scales. I am *not* interested in formal hierarchies but the relative capacity of organizations to do something to improve the situation or use their veto power to make things worse.

Sub catchment scale	Catchment scale
1.	1.
2.	2.
3.	3.

1. For all the organizations that you have added to the recall list could you please provide me with their contact details including an appropriate contact person.

Organization:
Contact person:

Organization:
Contact person:

Organization:
Contact person:

Organization:
Contact person:

Mapping of activities in the Berg River catchment

Appendix 4.2: Berg River catchment Recall List

		Name of organization	Typical contact person	R1. ACTIVE	R3a. INFO	R3b. INFO	R4. COLLAB
				Active in water manage-ment	Provides WQ info →	Receives WQ info ←	Collaborative partner
National Departments	1a	Department of Water Affairs					
	1b	Department of Water Affairs					
	2a	Working for Water					
	2b	Working for Water					
	3	Department of Agriculture					
	4	Department of Local Government					
	5	Department of Land Affairs					
	6	Department of Public Works					
Provincial departments	7	Department of Agriculture					
	8a	DEA&DP					
	8b	DEA&DP					
	9	Office of the Premier Western Cape					
	10	Department of Housing					
	11	Department of Local Government					
Municipalities	12a	West Coast District Municipality					
	12b	West Coast District Municipality					
	13	Cape Winelands District Municipality					
	14	Bergriver Municipality					
	15	Stellenbosch Municipality					
	16a	Drakenstein Municipality					
	16b	Drakenstein Municipality					
	17	Witzenberg Municipality					
	18	City of Cape Town					
	19	Swartland Municipality					
	20	Saldana Bay Municipality					
	21	Berg River Main IB					
	22	Benede Berg River IB					
	23	Berg River IB					
IRRIGATION BOARDS/WATER USER ASSOSIATIONS	24	Simonsberg IB					
	25	Perdeberg IB					
	26	Tulbagh WUA					
	27	Vier en Twintigrivier IB					
	28	Noord Agter Paarl IB					
	29	Suid Agter Paarl IB					
	30	Riebeek- Kasteel IB					
	31	Riebeek West IB Nr.1					
	32	Riebeek West IB Nr2					
	33	Simondium IB					

	34	Groenberg IB Nr1					
	35	Groenberg IB Nr2					
	36	Berg Pollution Action Committee					
	37	Goedverwacht Boerevereinigung					
Stakeholder groups	38	NAFU					
	39	Women on Farms					
	40	AGRI WC					
	41	WESSA					
	42	Cape Nature					
	43	CSIR					
	44	Stellenbosch University					
	45	University of the Western Cape					
	46	UCT					
	47	SANBI					
	48a	WWF (Water balance)					
	48b	WWF (BWI)					
	49	Prof Jo Barnes					
	50	Anchor Environmental					
	51	TCTA					
	52a	Aurecon					
	52b	Aurecon					
	53	Blue Science					
	54	Waterright consulting					
	55	St Helena WQ Trust					
	56	Berg River Estaury Forum					
	57	Provincial Water Quality task team					
OTHER							

Appendix 4.3: The creation of the final reciprocated network N

In order to be able to capture the direction of information flow in the network, the relation 'information exchange' was split into two sub questions*: From whom do you receive information on the Berg River? To whom do you provide information on the Berg River*? By asking the respondents to detail the direction of information flow, a better understanding was obtained of who was more a provider of information (and therefore a potential knowledge producer and transmitter) and who was a recipient of information.

Considering that each relation (info provide, info receive and collaboration) defines a different network, the three sets of network data were combined to create a multiplex network comprised of reciprocal relations.

For analyzing the communication flow in the network, the two relations 'Info providing' (r3p) and 'Info receiving (r3r)' were combined into one matrix. A new relation R3 = max(r3r,r3p)[1] was created using the Matrix Algebra function in UCINET. [2] The relation 'information exchange' (R3) was then transformed into a reciprocated relation using the minimum value as criterion for symmetrizing the relation.[3]. The new relation was labeled **INFO**. The relation 'collaboration' (R4) was symmetrized in the same manner and the new reciprocated relation was labeled **COLL.**

Chapter 2 has already pointed out that collaboration entails a large continuum of activities ranging from formal reporting as mandated by law, information exchange and advice, joint projects, and all the way to mutual trust relations. To be able to capture the collaborative network as accurately as possible and to account for this variation in the Berg River management network, the two relational networks (INFO and COLL) were combined into a single multiplex network (*N*) through the linear combination of the adjacency matrices. Thus, to create this final reciprocal network composed of the two relations, the matrix addition N = add(INFO, COLL) was performed in UCINET. This produced a 54 X 54 data matrix with values ranking from 0 to 2.
0 = no relation
1 = info exchange **or** collaboration
3 = info exchange **and** collaboration

Equations used for creating the different network matrices using Matrix Algebra:

- R3= max(R3p,R3r) (of the two values the higher value will be used)
- N = add(INFO,COLL)

Performed symmetrize function:

- INFO ➔ R3 symmetrised _minimum value
- COLL ➔ R4 symmetrised_minimum value

[1] The formula means that the exiting value in the matrix is replaced by the maximum value for either of the two sub relations. If an organisation receives **or** provides information or if a organisation receives **and** provides information it will score a value of 1. If an organisation neither receives nor provides information it will score a 0.

[2] The reason for first combining *Info receive* and *Info provide* and only then looking for reciprocal ties is based on the assumption that not everyone who provides info to another organisation will necessarily receive information from this organisation.

[3] Through this command the values in two corresponding cells are compared and only the lowest value is kept. This means that scoring a one for the new relation, the values in the two cells must have been one, meaning both actors acknowledged the relationship. This was done in UCINET through the command *Transform –symmetrize-minimum.*

Appendix 4.4: Overview of water management organizations (core WMOS)

The Department of Water Affairs (DWA)

The National office of the DWA is the operational arm of the Minister of DWA. Key responsibilities include, among others, the formulation of policies and strategies, regulation, and resource protection. Currently, DWA National fulfils the following functions: issuing of water licences, information management, IWRM planning, overseeing of water services and infrastructure development.

The regional offices, located in the nine Provinces, are primarily responsible for the implementation of management plans and strategies in specific regions which, for the most part, match the boundaries of the nine South African Provinces. On-going functions are concerned to a large extent the management of the water resources; they include institutional cooperation, stakeholder participation, investigation and advice, and development of Internal Strategic Perspectives (ISPs). The regional offices are also responsible for the management of water related infrastructure such as dams and intra-basin transfer schemes in their respective regions. The regional offices functions also as proto-CMAs in catchment management areas where CMAs have not been created. Hence, they are responsible for coordinating water management activities in the specific catchments.

The catchment management agencies (CMAs)

Originally, it was intended that the country should be divided into 19 water management areas (WMAs)[4] with each area being managed by one coordinating body i.e. a CMA. Due to the slow establishment of CMAs and concerns regarding the financial viability of CMAs in poorer WMAs, the original number of WMAs has been reduced to nine. While the boundaries still correspond to a large extent with hydrological boundaries, the newly created WMAs combine two or three catchments. At present, only two CMAs are operational. However, given the restructuring of the water management areas, they will also need to merge with other catchments in the near future.

CMAs are statuary bodies whose functions are directly assigned or delegated by the Minister.[5] One of their key functions is to coordinate water related activities of the different stakeholders and water management organizations (i.e. WUAs, municipalities and various provincial departments concerned with water management). Some other functions include the development of a catchment management strategy, and to promote community participation to monitor water use activities and compliance.

Water User Associations (WUAs)/ Irrigation Boards (IBs)

Similar to CMAs, WUAs are statutory bodies established by the Minister of DWA. WUAs are described under the Act as "cooperative associations of individual water users who wish to undertake water related activities for their mutual benefit (King and Pienaar, 2011: 53, NWA 1998 Chapter 8). The Act distinguishes between single sector WUAs, i.e. a group of users with similar interests (i.e. irrigators), and multi-sector WUAs. "The purpose of a WUA is to enable water users to cooperate and pool their resources (financial, human resources and expertise) to more effectively carry out water-related activities" (DWA 2005:39). Each WUA has a constitution and is regulated by the National Water Act. The Minister or the CMA may delegate powers and functions to the WUA. According to King and Pienaar (2011), the main intention for the creation of WUAs was to transform

[4] Although the delineation of water management areas is based on hydrological boundaries, digressions exists because of economic, geographic and social constraints (for justifications why some areas have been divided or merged, see Herrfahrdt-Pähle, 2010)

[5] According to the National Water Act, a CMA is responsible for "the protection, use, development, conservation, management and control of water resources in its water management area (Republic of South Africa 1998)

existing irrigation boards that were established under the water Act of 1956 to allow for the participation of black farmers and farm workers.

Municipalities

Municipalities do not have a clear legislative responsibility for water resource management (King and Pineaar, 2011). However, they play a key role in water management. It is for this reason that they have been included in the group of water management organizations in this study. Local and Metropolitan municipalities are so called **Water Service Authorities (WSAs**). They are responsible for managing water for domestic and industrial use.[6] Besides water supply and sanitation services they are also responsible for storm water management, solid waste disposal and land use planning. All of those activities are interlinked with water management and have a direct impact on the water resources in a catchment area. Municipalities may also act as **Water Service Provider (WSPs**) or they contract third parties (e.g. district municipalities or a private service provider) to be the WSP for their municipal area. A WSP is responsible for the practical implementation including day-to-day operations.[7]

Unlike the other WMOs (DWA, CMAs and WUAs), the municipalities are guided by the Water Service Act of 1997. They are also not directly responsible to the Minister of Water but to the Department of Local Government. An important planning instrument for municipalities is their Integrated Development Plans.[8] Within the IDPs, it is the Water Service Development Plan (WSDP) that spells out all the responsibilities and tasks required in water service delivery. However, a key issue that has been recognized by experts and researchers is that the WSDP is only concerned with drinking water provision. It does not refer to the role of municipalities in water resource protection nor to any responsibilities as far as integrated water resource management is concerned (Herrfahrdt-Pähle, 2010). According to the WRMS (2004), WSDPs should be in alignment with the CMS but since such strategies for most catchment areas do not exist, the vital integration between water service provision and water resource management is further inhibited (Herrfahrdt-Pähle, 2010).

[6] According to the Constitution of South Africa and the Water Service Act of 1997 it is the responsibility of local government to provide basic services such as sanitation and drinking water to their constituencies.

[7] Among the tasks are the provision of potable water, treating wastewater and effluent, water infrastructure repairs, and preventative as well as revenue collection and related financial management.

[8] They are intended to coordinate the work of local and other spheres of government as well as to align the sector plans. IDPs are also the result of public participation in its analyses and planning phases (Schreiner and Hassan et al., 2010). They are renewed every 5 years.

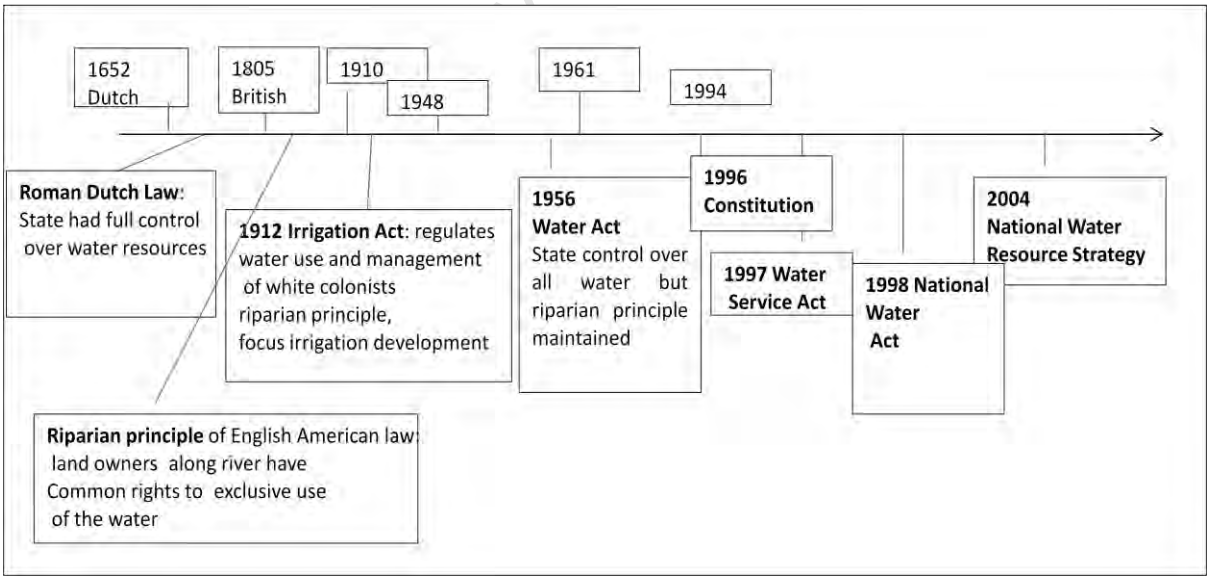
Appendix 4.5: Water management in South Africa: sketching a historically embedded water governance system

In this Appendix, historic processes are highlighted which will help in the understanding of the configuration of actor relations in the Berg catchment.

During the Apartheid era water, management was highly centralized and served the interest of the white minority (Funke et al., 2007). Under the discriminatory apartheid rule, the majority of South Africans (mainly its non–white citizens) did not have access to water for productive use nor did they possess any legal claims with regard to land and water rights. This legacy of inequality that became institutionalized far beyond the water sector can be traced back more than 300 years to the period of colonial rule under the Dutch and later under the British (King and Pienaar, 2011). Based on the riparian principle first introduced through Dutch rule during the colonial period, water rights were tied to land rights (King and Pienaar, 2011). That is, the owner of a piece of land was entitled to all surface and ground water on his or her property. After the passing of the Native Land Act of 1913 this meant that the majority of South Africans had no legal water rights since only whites could own land.

Despite the fact that water management was centrally controlled by the state, which had adopted a technocratic approach based on engineering solutions, water management remained fragmented among a variety of state organizations (e.g. DWA, the Homeland governments responsible for service provision to non-white settlements and municipalities responsible for service provision for white settlements) (Herrfahrdt-Pähle, 2010). The result was huge discrepancies of water provisions to white and non-white communities but also between rural and urban areas (King and Pienaar, 2011).

Box 4.8.1 Critical historic events shaping South Africa's water governance system



Source: adapted from Funke et al., 2007 and King and Pienaar, 2011.

After the end of the Apartheid era in South Africa, the newly democratically elected government started a water reform process which had the aim of redressing past racial discrimination and of establishing a more efficient water management system through which equity, sustainability and economic growth could be achieved. Under the Constitution of 1996 and the National Water Act of 1998, water became a public good and a "commons" (Funke et al., 2007). The Constitution further guaranteed the right to water for every citizen (Republic of South Africa, 1996). The Minister of

Water Affairs and Forestry (now Water and Environmental Affairs (DWA)) became the custodian of South Africa's water resources on behalf of the national government (King and Pienaar, 2011). Acting on behalf of the Minister, the role of the DWA was to develop and implement all policies and instruments related to the National Water Act. The regional offices of DWA were mandated to implement the policies in the nine regions (which match to a large extent the nine provinces) (King and Pienaar, 2011).

A **decentralization approach** underpinned the institutional reform of South Africa's water governance system. Hence, it was intended that important functions should be moved to appropriate regional and local organizations. The aim was to ensure that those previously excluded should have equitable access and also participate proactively in water resource management decision making; and to enable users and stakeholders to participate more effectively in the management of their water resources. The Act called for the establishment of new water management organizations at the regional and local level i.e. CMAs and WUAs. The CMAs operative at catchment scale are supposed to play a pivotal role in water management and are intended to take over much of the management functions from DWA. Until their establishment, the regional offices of DWA will act as proto-CMAs. King and Pineaar (2011:53) state that "[t]he vision …was one of decentralized management of water resources, with DWA as the custodian of the nation's water sources, decentralized CMAs as catchment-based management institutions, and water user associations as locally-based organizations managing shared water resources on behalf of their members".

The **institutional reform** was also influenced by the new approaches to natural resource management that had gained momentum in the international area. The National Water Act embraces, for example, the integrated water resource management (IWRM) approach, which promotes the coordinated development and management of water and land so as to maximize economic and social welfare without compromising the sustainability of vital ecosystems (DWAF, 2004). As a consequence, the catchment and its hydrological boundaries were identified to be the most appropriate unit for realizing participatory and inclusive water management in South Africa. Other important cornerstones of the institutional reform were the establishment of the human and the ecological reserve, and the introduction of compulsory licensing, i.e. water use rights were no longer attached to land rights. It is important to note that the institutional reform has been slow and patchy and which has had a direct impact on all actors involved in the water sector.

Besides the National Water Act, South Africa's water governance system is also been shaped by the National Water Service Act. Under the Act, domestic and industrial water supply as well as sanitation has been assigned to local government (i.e. it has become the responsibility of the municipalities).[9] In recent years an apparent dichotomy between two acts (or the creation of a dual structure in the governance system) has been identified as one of the key obstacles in achieving an integrated management system. This issue is also highlighted in Chapter 5 of this thesis.

The overarching instrument for managing South Africa's water resources is the National Water Resources Strategy. Its purpose is to ''set out the strategies, objectives, plans, guidelines and procedures of the Minister and institutional arrangements relating to the protection, use, development, conservation, management and control of water resources'' (DWAF, 2004: 8). The Strategy is supposed to be renewed every five years. Key instruments at the catchment and local

[9] In 1994 DWA was actually mandated to develop the necessary water supply infrastructure and to provide water services but this responsibility was moved to local government after the local government elections in 2000. (pers comm. E. Enright 2010; Herrfahrdt-Pähle, 2010)

level are supposed to be catchment management strategies (CMS)[10] the Water Service Development Plan which form part of the Municipal Integrated Development Plans and local plans of WUAs.

To summarize, during the Apartheid era a highly centralized water governance system existed with government controlling most aspects of water management and little engagement with stakeholders existed except to regulate their practices. Hence, no culture of participation was fostered. Only a limited number of non-state actors, namely commercial agriculture and later industry were able to actively influence water management (Meissner et al., 2013). Industry and commercial agriculture were, for example, given preferential treatment to ensure the self-sufficiency of the South African state to counter international sanctions against apartheid government. Many stakeholders and their needs were not only marginalized but completely ignored by the state. All of this has had a significant impact on the current configuration of the actor relations in South Africa's water governance system. Hence, while political change provided a great opportunity for a radical shift in water governance, the transition from a highly central and exclusive water governance regime is extremely challenging and requires the reconfigurations of many actor relations.

Appendix 4.6 Pre-study list of interviewees

Name	Organization	Interview Date
1. Wilna Kloppers	DWA	28.11.09
2. Cathy Bill	DEA&DP	20.01.10
3. Willie Enright	Wateright Consulting	12.4.10
4. Rashid Kahn	DWA	15.7.09
5. Jo Barnes	Stellenbosch University	15.7.09
6. JD Kirsten	Commercial farmer	14.7.09
7. Boubon-Lefty	Commercial farmer	14.7.09
8. Bertrand van Zyl	DWA	12.11.09
9. Dennis Boesak	Emerging Farmer	15.01.10
10. Jenny Day	Fresh water research Unit, UCT	16.11.09
11. Jimmy Knaggs	Drakenstein Municipality	14.7.09
12. Doreen February	Consultancy (CMA Ref. Group)	15.7.09
13. Daniel Seale	NAFU	23.11.09

[10] In catchments were no CMA exist, and consequently CMS, DWA uses their Internal Strategic Perspectives (ISPs) as guiding planning instrument.

Appendix 4.7: Arriving at the final actor set of 54 organizations-adding and removing organizations

As mentioned in Chapter 4, in addition to organizations listed in the original recall list, the respondents were provided with the possibility of adding organizations that they considered to be important actors for the management of the Berg catchment area.[11] New organizations were added to the original recall list only if they were mentioned by several other respondents. This technique increased the likelihood that important organizations are not missed while at the same time ensuring that the actor network is kept to a manageable size (Wasserman and Faust ,1994).

In total, seven organizations were added to the original actor set that was listed on the recall list. Their active engagement in the management of the Berg River was affirmed by more than two survey respondents.

Table 4.7.1 listing the organizations added to the additional recall list

Organization	Number of affirmations
Woolworths	3
Birdlife SA	3
Natural Resources Ref group Drakenstein	3
Agter Groenberg conservancy	3
Saldana Bay WQ Trust	3
Westcoast Cape Biosphere Reserve	3
Southern Waters	5

Seven organizations that were part of the original recall list were not included in the analysis. Six of the organizations did not meet the requirements (affirmation by more than two organizations and one collaborative relation, either info exchange or collaboration, with at least one other organization).[12] One actor who had received quite a few affirmations from other actors was also removed from the actor set because at the time of the study it no longer participated actively in the management of the Berg River.[13] In addition, the three regional universities were also removed from the actor set. While the universities are quite important for knowledge production, none of them were directly involved (i.e. through targeted long term interactions) in collaborative activities focused on the Berg River.[14] When compared to the consultancies, the knowledge created by the universities did not necessary feed back into the management of the Berg. Most of the consultancies, on the other hand, have actively contributed to reports and strategies that relate to the management of the Berg River.

Table 4.7.2 Organizations from the original recall list which were removed from the actor set

Organizations

[11] Prell (2011) states that vital for the accuracy of such an approach is to first identify the key informants who have a good understanding of the network. We used an extensive pre study to identify relevant key informants.

[12] For the three government departments, the researcher could also not identify a representative that was involved in the management of the Berg River. The reason why the national departments had been identified by key informants from the pre study is because they should be involved in the management of the Berg River based on their mandates.

[13] The reason why the actor was mention so often is because the organization was very involved in the management of the Berg River during the construction of the Berg River dam. During this period, 2007 to 2009, many organizations had interacted with this organization. However, these management activities have now been handed over to the Department of Water.

[14] Although a number of researchers (mainly students) from the different universities are conducting specific research activities relating to the Berg River, these are mainly on an individual and short term basis.

Department of Local Government (CoGTA)
Department of Land Affairs
Department of Public Works
TCTA
NAFU
Goedverwacht Boervereinigung
Women on Farms
UCT
Stellenbosch University
University of the Western Cape

Furthermore, it needs to be noted that of the 57 organizations from the original recall list, four did not complete the network survey. One actor decided not to participate in the study, stating time constraint as the main reason. For the other two organizations. representatives dedicated to activities in the Berg could not be identified at the time of the fieldwork. Individuals that previously were involved had left their positions.

Dealing with the three non-participating actors required more consideration. It became evident from the qualitative data that all of them have made contributions to the network and the management of the catchment area. Indeed, the actor that was unable to partake in the survey because of time constraints was mentioned by as many as 12organizations with several of the respondents stating regular collaborative interaction. Based on the qualitative understanding of the network and after consulting the SNA literature on how to handle missing data (Borgatti et al 2013) it was decided to use the information provided by the other organizations in order to complete the network data for these three actors. More specifically, the receiving ties that each actor received for the network relations 'information exchange' and Collaboration were transposed. For the relation provide information to the transpose of the relation receive information from was used. For the relation receive information from the transpose of provide information to was used. For the relation collaboration the direct transpose was used.

The handling of missing network data in this manner was an important step in ensuring that important relational data did not get lost. The network data obtained from the other survey respondents affirmed that actor (#39) was quite a critical actor (knowledge source) in the network. This was also supported by interviews and participant observation in a large number of meetings. While the other two organizations are more indirectly involved in management activities, their resources enhance the ability to manage the catchment area. The research institution (#47) is a key source for ecological knowledge in the region and the national department provides important financial resources to its provincial counterpart. If the relations of the three actors to other organizations in the Berg management network had been ignored, it would have distorted the analysis and interpretation of the network. After all the considerations mentioned above, the final actor set that makes up the Berg management network is comprised of 54 organizations.

Table 4.7.3 List of included actors, using transpose method

Organization	ID	App	Justification
Department of Agriculture (National)	2		Financial support to the landcare program
J.B	49		WQ knowledge
SANBI	47		Ecological knowledge

Appendix 4.8:Berg catchment related reports

ANCHOR Environment:
http://www.anchorenvironmental.co.za/
Berg Estuary Management Plan
• Berg Estuary Situation Assessment
• Berg Estuary Draft Management Plan-Final October 2009
• Konsepbestuursplan vir die Bergriviermond-Final October 2009
Berg River Baseline Monitoring Reports
• VOLUME 1. Introduction to the Berg River Catchment
• VOLUME 2. Part 1. River Baseline Monitoring
• VOLUME 2. Part 2. River Baseline Monitoring
• VOLUME 3. Estuary and Floodplain Environment
• VOLUME 4. Social and Cultural Aspects
• VOLUME 5. Synthesis
• VOLUME 6. Berg River Groundwater Atlas
Drakenstein Municipality:
• Pollution of the Berg River_Status of projects undertaken by Drakenstein Municipality July 2008
• Pollution of the Berg River_River Improvement Project_June 2007
• River Environmental Management Plan_Draft_Feb. 2009
DWA :
• Profile on WA in the Berg, Breede, Gouritz & Olifants/Doorn WMAs March 2005
• DWA (Department of Water Affairs). 2007. *Western Cape Water Supply System Reconciliation Strategy Study. Summary Report and Reconciliation Strategy Report*
• Green Drop report
• River management strategy for the Berg water management area of Western Cape, Scoping report Oct. 2008
• Berg Report 2004 Health River programme
Western Cape:
• Berg River Quality Task Team Report. 2009. Western Cape Department of the Premier Branch: March- April 2009 Governance & Integration Chief Directorate Policy Development & Intergovernmental Relations
• WCDEA&DP (Department of Environmental Affairs & Development Planning), 2011. Integrated Water Resources Management Action Plan. Department of Environmental Affairs & Development Planning, Government of the Western Cape Province, Cape Town.
Others:
• Louw, D. 2008. Possible Impacts of water pollution in the Berg River irrigation region. Paper for the Upper Berg River Irrigation Board.
• Colvin, J. et al 2010. FETWater CMA Expertise Development Network K5-1947-B.Report on Deliverable 5
• Brown and Magoba. 2009. Rivers and Wetlands of Cape Town. WRC report
• Winter et al. 2010. Sustainable options for community-level management of grey water in settlements without on-site water borne sanitation WRC K5/1654

APPENDIX 5.1.: Overview of all SNA Measures including findings

	Analysis	Method	Aim	Finding	Network
	Basic whole Network measures	Degree and Betweenness centrality Density Centralization	Identification of relevant actors and the level of interaction among them To assess how well the network is connected and how power and exchange (info and resources) are distributed in the network	• Sparse network in which all actors are directly or indirectly connected • Composed of a large number of diverse organizations • 2 central actors	Network N
COHESION	Attribute based sub-group analysis	Group density and centralization (A) Core WMOs vs others (B) Comparison of four groups: • DWA • IBs/WUA • LG* • No-WMOs (C) Sub-population IBs • Visualized sub-graph • Ego network central actor (D) Sub-population LG & DWA • Visualized Sub-graph • Ego network central actor	• Assessing the cohesion among core WMOs o Their role in the network	• Low interaction among WMOs • Cohesion based on tie distribution better among non-WMOs • Cohesion among WMOs dependent on 2 central actors • Strong cohesion within IBs • Low interaction within group of municipalities • Non WMOs have on average more ties then WMOs • 2 central actor are broker/gatekeeper within their groups as well as among the two groups of local WMOs • IBs star-like network structure • Diverse Ego network of Main IB • Structural difference btw WUA and 24 IB in comparison to rest of IBs • limited learning and collaboration opportunities for most of the smaller IBs •	Network N

	Comparison information exchange and collaboration	Density and composition	• How does the operational level self-organize • Variation in mandated and non-mandated actors, administrative levels	• Information exchange primary structured along formal relation • Collaboration seems to form along choice relations (informal???) ➔Shows location of capacities and incentives structures in the network	Information Network, Collective action' Network
	Cohesive sub-group analysis	Girvan-Newman Algorithm	• To identify 'collaborative' clusters i.e. organizations that have self-organized into groups	• Network represents "choice" relations • Except for WQ Task team most relations within the groups are informal relations or trust relations • Heterogeneous groups • DWA occupies only a peripheral position • Main IB remains central actor	Collective action' Network
		Group density and centralization	• To examine the interaction across cohesive sub-groups ➔ insight into catchment wide collective action	• Low interaction across sub-groups	Main component of Collective action' Network
		G-F Brokerage (gatekeeper and Representative)	• To identify actors important for linkages	• Bridging organizations are diverse	Collective action' Network without isolates

	Measurement	Method	Aim	Finding	Network
HETEROGENEITY	core-periphery analysis	core/periphery continuous function	to detect marginalized organizations	• Dependent and major stakeholders take peripheral positions	Network N(v)
	n/a	• # of ties from eco sources to other non-eco actors • # of sources non-eco actors have direct access to (w/o considering DWA)	Embeddedness of ecological knowledge sources	• Ecological knowledge, in particular scientific ecological knowledge, not well embedded • Many core WMOs (14 of 24) have only access to ecological knowledge through DWA which currently is not a reliable knowledge source • Strong role of consultancies in generation of ecological knowledge • Municipalities with internal expertise have access to ecological knowledge sources	Network N(v)
	Cross-boundary linages	E-I Index (modes)	To examine information exchange among modes of governance	• Organizations from the same governance mode tend to exchange more information with each other than with organizations from different modes • Market actors have a external orientation for info exchange	Information Network
			To examine collaboration among modes of governance	• There is strong tendency for organizations to form collaborative ties with organizations belonging to the same governance mode • Market actors are most collaborative actors (89%) actors have strong internal orientation for collaboration • Low collaboration exist between market and government actors • Organizations belonging to the hierarchical mode are the least collaborative (63%)	'Collective action' Network
		E-I Index (sectors)	To examine information exchange among sectors	• The tendency to exchange information within a sector is greater than among sectors	Information Network

			To examine collaboration among sectors	• Intra-sectoral collaboration is higher than inter-sectoral collaboration. • A certain level of inter-sectoral collaboration does exist • The agricultural sector appears to be the strongest sector with a very high level of internal collaboration and a significant number of external collaborative ties • The consultancy and research sector play a strong role in info provider to other sectors but are don't maintain this role for collaboration • Very low information exchange and collaboration can be observed in the basic needs sector	Collective action' Network
		G-F brokerage roles of specific actors	Role of individual actors in establishing cross-scale linkages for: inter sectoral integration, bridging of governance modes and connecting cohesive subgroups	• important bridging roles for **inter-sectoral integration**: DoA_WC, Cape Nature the Main IB the two district municipalities (WCDM, CWDM) o DWA does not contribute to intra or inter-sectoral collaboration • important bridging roles for **modes**: the Main IB, Cape Nature DoA_WC, , and BREF o brokerage roles do not seem to be mode dependent. • Bridging actors across **cohesive sub-groups**: Main IB, Cape Nature, Lower IB, BREF, WCDM	Network N

Appendix 5.2: Table of Degree and Betweenness centrality scores Network N

ID	Degree	NrmDegree	Share
DWA	21	39.62264	0.067308
Main IB	18	33.96227	0.057692
IB pollution committee	17	32.07547	0.054487
Wateright	14	26.41509	0.044872
WCDM	13	24.5283	0.041667
CapeNature	13	24.5283	0.041667
DS_M	12	22.64151	0.038462
WfW	12	22.64151	0.038462
DoA_wc	12	22.64151	0.038462
CWDM	11	20.75472	0.035256
DEADD	11	20.75472	0.035256
Provincial WQ team	10	18.86792	0.032051
Lower IB	10	18.86792	0.032051
J.B.	8	15.09434	0.025641
Upper IB	8	15.09434	0.025641
BEMF	7	13.20755	0.022436
SANBI	6	11.32076	0.019231
WWF	6	11.32076	0.019231
CWBR	6	11.32076	0.019231
Aurecon	5	9.433962	0.016026
24 IB	5	9.433962	0.016026
CSIR	5	9.433962	0.016026
SB_M	5	9.433962	0.016026
AGRI WC	5	9.433962	0.016026
SW	4	7.54717	0.012821
BR_M	4	7.54717	0.012821
CoCT	4	7.54717	0.012821
St. H. WQ Trust	4	7.54717	0.012821
Tulbagh WUA	4	7.54717	0.012821
Anchor	3	5.660378	0.009615
SDB_M	3	5.660378	0.009615
35	3	5.660378	0.009615
AGC	3	5.660378	0.009615
NR RGDS	3	5.660378	0.009615
DoLG _wc	3	5.660378	0.009615
WESSA	3	5.660378	0.009615
28	3	5.660378	0.009615
BL SA	2	3.773585	0.00641
SL_M	2	3.773585	0.00641
IB Sb	2	3.773585	0.00641
30	2	3.773585	0.00641
31	2	3.773585	0.00641
32	2	3.773585	0.00641

34	2	3.773585	0.00641
WB_M	2	3.773585	0.00641
Perdeberg IB	2	3.773585	0.00641
33	2	3.773585	0.00641
29	2	3.773585	0.00641
WWs	1	1.886792	0.003205
DoA_N	1	1.886792	0.003205
OoP _wc	1	1.886792	0.003205
SB WQ Trust	1	1.886792	0.003205
Blue Science	1	1.886792	0.003205
DoH _wc	1	1.886792	0.003205

Betweenness Centrality

ID	Betweenness	nBetweenness
DWA	420.8877	30.54338
Main IB	283.5919	20.57996
IB pollution committee	158.6105	11.51019
Provincial WQ team	133.8628	9.714284
WCDM	128.5843	9.331224
Wateright	124.988	9.070244
CapeNature	106.9162	7.758799
WfW	101.2405	7.346917
DS_M	97.16527	7.05118
DoA_wc	94.80348	6.879788
Lower IB	72.85413	5.286946
DEA&DP	67.51672	4.899617
CWDM	62.15449	4.510486
SANBI	56.87794	4.127572
WWF	52.45202	3.806387
SDB_M	52	3.773585
C W BR	40.72697	2.955513
BMEF	36.80611	2.67098
Aurecon	22.84802	1.658056
CSIR	17.84614	1.295075
J.B.	13.74806	0.997682
CoCT	9.907936	0.719008
Tulbagh WUA	8.87489	0.644041
Upper IB	8.374352	0.607718
24 IB	7.800045	0.566041
Anchor	5.911143	0.428965
AGRI WC	5.899707	0.428135
SW	4.410256	0.320048
BR_M	4.237285	0.307495
St. H. WQ Trust	4.237285	0.307495
SB_M	3.445238	0.250017
WB_M	2.187302	0.15873

WESSA	0.833333	0.060474
NR RGDS	0.4	0.029028
DoLG_wc	0	0
28	0	0
33	0	0
30	0	0
SB IB	0	0
SB WQ Trust	0	0
34	0	0
BL SA	0	0
SL_M	0	0
29	0	0
Blue Science	0	0
31	0	0
32	0	0
OoP_wc	0	0
Perdeberg IB	0	0
35	0	0
AGC	0	0
WWs	0	0
DoA_N	0	0
DoH_wc	0	0

Appendix 5.3: Degree centrality 'collective action' network

ID	Degree	NrmDegree	Share
Main IB	15	28.30189	0.10274
CapeNature	11	20.75472	0.075342
WCDM	8	15.09434	0.054795
Provincial WQ team	8	15.09434	0.054795
DoA_wc	8	15.09434	0.054795
Wateright	7	13.20755	0.047945
WfW	6	11.32076	0.041096
CWDM	6	11.32076	0.041096
Upper IB	5	9.433962	0.034247
BMEF	5	9.433962	0.034247
WWF	5	9.433962	0.034247
Lower IB	5	9.433962	0.034247
DS_M	4	7.54717	0.027397
CWBR	4	7.54717	0.027397
IB pollution commitee	4	7.54717	0.027397
Consultancy JB	4	7.54717	0.027397
Tulbagh WUA	3	5.660378	0.020548
DEA&DP	3	5.660378	0.020548
28	2	3.773585	0.013699
SB_M	2	3.773585	0.013699
AGC	2	3.773585	0.013699
SW	2	3.773585	0.013699
BR_M	2	3.773585	0.013699
AGRI WC	2	3.773585	0.013699
DoLG _wc	2	3.773585	0.013699
DWA	2	3.773585	0.013699
Perdeberg IB	1	1.886792	0.006849
WB_M	1	1.886792	0.006849
32	1	1.886792	0.006849
29	1	1.886792	0.006849
34	1	1.886792	0.006849
35	1	1.886792	0.006849
33	1	1.886792	0.006849
CSIR	1	1.886792	0.006849
WESSA	1	1.886792	0.006849
SB IB	1	1.886792	0.006849
OoP _wc	1	1.886792	0.006849
SANBI	1	1.886792	0.006849
SB WQ Trust	1	1.886792	0.006849
31	1	1.886792	0.006849
SDB_M	1	1.886792	0.006849
24	1	1.886792	0.006849

Anchor	1	1.886792	0.006849
Aurecon	1	1.886792	0.006849
30	1	1.886792	0.006849
CoCT	0	0	0
DoA_N	0	0	0
WWs	0	0	0
SL_M	0	0	0
Blue Science	0	0	0
St. H. WQ Trust	0	0	0
BL SA	0	0	0
NR RGDS	0	0	0
DoH _wc	0	0	0

Appendix 5.4: List of SNA respondents - qualitative interview data

ID	Organisation	Date
S-1	Wateright consulting	14.01.11
S-2	Berg River Main IB	12.04.11
S-3	Drakenstein Municipality	04.02.11
S-4	IB Pollution committee	12.04.11
S-5	Perdeberg IB	12.05.11
S-6	Upper Berg IB	28.04.11
S-7	Stellenbosch Municipality	24.02 11
S-8	Drakenstein Municipality	04.02.11
S-9	Saldanha Bay Water Quality Forum Trust	08.09.11
S-10	West Coast District Municipality	04.04.11
S-11	West Coast District Municipality	07.04.11
S-12	Witzenberg Municipality	08.09.11
S-13	St Helena Bay Water Quality Trust	08.08.11
S-14	CapeNature	26.05.11
S-15	DWA Regional office Resources Protection	04.04.11
S-16	Department of Agriculture, Western Cape	1.7.11
S-17	Saldanha Bay Municipality	07.04.11

Appendix 5.5 List of all Organizations and their IDs

Organisation	ID
Department of Water Affairs	DWA
Working for Water	WfW
Department of Agriculture, National	DoA
Department of Agriculture, Western Cape	DoA_wc
Department of Environmental Affairs and Development Planning, Western Cape	DEA&DP_wc
Office of the Premier Western Cape	OoP_wc
Department of Housing, Western Cape	DoH_wc
Department of Local Government, Western Cape	DoLG_wc
West Coast District Municipality	WCDM
Cape Winelands District Municipality	CWDM
Bergriver Municipality	BR_M
Stellenbosch Municipality	SB_M
Drakenstein Municipality	DS_M
Witzenberg Municipality	WB_M
City of Cape Town	CoCT
Swartland Municipality	SL_M
Saldana Bay Municipality	SDB_M
Berg River Main Irrigation Board	Main IB

Benede Berg River IB	Lower IB
Berg River Irrigation Board	Upper IB
Simonsberg IB	SB IB
Perdeberg IB	Perdeberg IB
Tulbagh WUA	Tulbagh WUA
Vier en Twintigrivier IB	24 IB
Nord Agter Paarl IB	28
Suid Agter Paarl IB	29
Riebeeck- Kasteel IB	30
Riebeeck West IB Nr. 1	31
Riebeeck West IB Nr. 2	32
Simondium Irrigation Assosiation	33
Groenberg IB Nr 1	34
Groenberg IB Nr 2	35
Berg Pollution Action Committee	IB pollution
AGRI WC	AGRI WC
WESSA	WESSA
Cape Nature	CapeNature
CSIR	CSIR
SANBI	SANBI
WWF	WWF
Prof Jo Barnes	J.B.
Anchor Environmental	Anchor
Aurecon	Aurecon
Blue Science	Blue Science
Waterright consulting	Wright
St. Helena Water Quality Trust	St. H. WQ Trust
Berg River Estuary Forum	BREF
Provincial Berg River water quality task team	WQ task team
Woolworths	WWs
Birdlife SA	BL SA
Natural Resources Ref. group Drakenstein	NR RGDS
Agter Groenberg conservancy	AGC
Saldana Bay WQ Trust	SB WQ Trust
Cape Westcoast Biosphere Reserve	C W BR
Southern Waters	SW

Appendix 6.1 List of Interviewees Collective Action Initiatives

ID	Organisation	Date
I-1	Department of Water Affairs	08.04.11
I-2	Department of Water Affairs	04.04.11
I-3	Working for Water	24.04.12
I-4	Working for Water	08.04.11
I-5	Department of Agriculture WC	01.07.11
I-6	Department of Agriculture WC	04.02.11
I-7	West Coast District Municipality	07.04.11
I-8	Stellenbosch Municipality	24.02 11
I-9	Stellenbosch Municipality	31.01.13
I-10	Stellenbosch Municipality	31.01.13
I-11	Drakenstein Municipality	02.04.11
I-12	Drakenstein Municipality	02.04.11
I-13	Berg River Main IB	12.04.11
I-14	Benede Berg River IB	20.05.10
I-15	Berg River IB	28.04.11
I-17	Perdeberg IB	12.05.12
I-18	Vier en Twintigrivier IB	05.05.11
I-19	Noord Agter Paarl IB	19.05.11
I-20	Suid Agter Paarl IB	14.06.11
I-21	Riebeek West IB Nr2	10.05.11
I-22	Berg Pollution Committee	12.04.2011
I-23	CapeNature	26.05.11
I-24	CapeNature	28.07.11

I-25	WWF	0.06.05.11
I-26	Waterright consulting	10.04.12
I-27	IB Pollution Committee	17.03.12
I-28	BMEF Member	03.06.11
I-29	BMEF Member	15.05.13
I-30	Office of the Premier	25.02.11
I-31	DEA&DP	21.04.11
I-32	WCDM	04.04.11
I-33	DoA_wc	01.07.11
I-34	DEA&DP	11.04.11
I-35	DoA	18.04.11
I-35	Stellenbosch	15.06.11