Westfälische Wilhelms-Universität Münster

Boundary Work for Collaborative Water Resources Management

Conceptual and Empirical Insights from a South African Case Study

Esther Irene Dörendahl

Landschaftsökologie

Boundary Work for Collaborative Water Resources Management: Conceptual and Empirical Insights from a South African Case Study

Inaugural-Dissertation
zur Erlangung des Doktorgrades der Philosophie
im Fachbereich Geowissenschaften
der Mathematisch-Naturwissenschaftlichen Fakultät
der Westfälischen Wilhelms-Universität Münster

Vorgelegt von
Esther Irene Dörendahl, geb. Geiß
aus Ndola, Sambia

- 2015 -

Dekan:	**Prof. Dr. Hans Kerp**
Erstgutachter:	**Prof. Dr. Tillmann Buttschardt**
Zweitgutachter:	**Prof. Dr. Uwe Schneidewind**
Tag der mündlichen Prüfung:	**15.07.2015**
Tag der Promotion:	**15.07.2015**

Esther Irene Dörendahl

Boundary Work for Collaborative Water Resources Management

MV WISSENSCHAFT

Westfälische
Wilhelms-Universität
Münster

Wissenschaftliche Schriften der WWU Münster

Reihe XVII

Band 2

ulb
Universitäts- und
Landesbibliothek Münster

Esther Irene Dörendahl

Boundary Work for Collaborative Water Resources Management

Conceptual and Empirical Insights from a South African Case Study

MV WISSENSCHAFT

Wissenschaftliche Schriften der WWU Münster
herausgegeben von der Universitäts- und Landesbibliothek Münster
http://www.ulb.uni-muenster.de

Bibliografische Information der Deutschen Nationalbibliothek:
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Dieses Buch steht gleichzeitig in einer elektronischen Version über den Publikations- und Archivierungsserver der WWU Münster zur Verfügung.
http://www.ulb.uni-muenster.de/wissenschaftliche-schriften

Esther Irene Dörendahl
„Boundary Work for Collaborative Water Resources Management. Conceptual and Empirical Insights from a South African Case Study“
Wissenschaftliche Schriften der WWU Münster, Reihe XVII, Band 2

ISBN 978-3-8405-0131-9 (Druckausgabe)
URN urn:nbn:de:hbz:6-38229604351 (elektronische Version)

direkt zur Online-Version:

Satz: Esther Irene Dörendahl
Umschlag: MV-Verlag
Druck und Bindung: MV-Verlag

Esther Irene Dörendahl

Boundary Work for Collaborative Water Resources Management

Conceptual and Empirical Insights from a South African Case Study

2015

ACKNOWLEDGEMENTS

Life is what happens, while you are busy making other plans… This resolution basically summarizes the complexities of this research project, on a professional analytical level, as well as on a private level. The research project was characterized by ups and downs, passed points of potential returns and points of no returns. The process was enabled and influenced by the following people, to whom I want to express my deepest thanks[1]:

I am utmost grateful for academic support and inspiration by Peter Mollinga, Irit Eguavoen, Uta von Winterfeld and Wolfgang Sachs during study design and field research. Tillmann Buttschardt and Uwe Schneidewind were fantastic academic supervisors during data analysis and write-up. I am very thankful to my friend Vanessa Stauch, who conducted quick and effective proof-reading between work and family-life and who was always available for exchange during final write-up. I am especially thankful for Harry Biggs and Dirk Roux from South Africa National Parks (SANParks) Scientific Services, who were both, a great moral and intellectual support during field research and also later. I am further utmost thankful to SANParks Scientific Services for facilitating this study and by allowing to also very critically assess their own organization. SANParks further provided any support, when required, including support through research assistants, translators, office space as well as accommodation. I am thanking Eiman Karar from the South African Water Research Commission, who established the first link to SANParks. I am thankful for Christo Fabricius from Nelson Mandela Metropolitan University (NMMU) who supported me throughout the field research period through informal collaboration with NMMU and the Sustainability Research Unit (SRU), George Campus, for providing a safe and friendly home on campus, and for an intellectually inspiring research environment.

The study was inherently dependant on close collaboration with a broad variety of local stakeholders, and I want to express my deepest thanks to all interviewees and participants in the case study, for their valuable time, trust, con-

[1] I kindly ask to excuse that I did not include academic titles in the acknowledgements.

tributions, friendliness, openness and insights. I am very grateful for my awesome research assistants Zoë Luhdo, Marco Pohl and Michael Pule Kgakatsi for being highly supportive and open-minded, providing great practical help and for sharing fun (and many hurdles) during field research. I am utmost grateful for my 'South African cultural interpreters', mentors and close friends Karin Hendricks, Annah Rose Nyadzane Telela and Angela Gaylard, who opened my eyes to multiple aspects of collaboration in the 'rainbow nation', on a professional and even more important on a private level.

I am deeply thanking my parents, Anne and Paul Geiß, who instantly came to South Africa during emergency, providing hands-on practical and great emotional support, which changed a seemingly 'obligatory point of return' into a 'chance to persist'. And I am deeply thanking my husband Karsten Dörendahl for fully and steadily supporting this (rough) journey of international research and for his persistent support to never give up. I am also thanking my two daughters, Alma Sofia and Mila Malaika, both born during research, for being reason, obstacle and motivation at the same time, and for giving meaning, when extensive exhaustion questioned all meanings.

Düsseldorf, May 2015

The PhD study was conducted in affiliation with three German organisations: the Institute of Landscape Ecology (ILÖK), University of Münster, Wuppertal Institute for Climate, Environment and Energy (WI) and the Centre for Development Research (ZEF), University of Bonn. The project was registered in South Africa with South Africa National Parks Scientific Services. Nelson Mandela Metropolitan University, George Campus, granted informal collaboration and hosted me as guest researcher during field research. The project was funded by the German Federal Ministry of Education and Research through a PhD-Grant under the IPSWaT-programme, and by a grant from the Dr. Hermann Eiselen Doctoral Programme of the Foundation fiat panis.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF BOXES

LIST OF TABLES

APPENDIX

LIST OF ABBREVIATIONS

AEAM	Adaptive Environmental Assessment and Management
AM	Adaptive Management
ANC	African National Congress, Republic of South Africa's social democratic political party
atlas.ti	Software for qualitative data analysis
B&B	Bed and Breakfast (Hostel)
CBD	Convention on Biological Diversity
CDW	Community Development Workers
CDWP	Community Development Workers Programme
CMA	Catchment Management Agency
CMF	Catchment Management Forum
CMS	Catchment Management Strategy
COM	Stakeholder from the Community
CONS	Stakeholder from the conservation sector
CSIR	Council for Scientific and Industrial Research
CSO	international Civil Society Organisations
DEA	Department of Environmental Affairs
DM	District Municipality
DPSA	Department of Public Service and Administration
DWA	Department of Water Affairs (later DWS)
DWAF	Department of Water Affairs and Forestry (then DWA, then DWS)
DWS	Department of Water and Sanitation (current name)
EA	The Ecosystem Approach
EDM	Eden District Municipality
EIA	Environmental Impact Assessments
EU	European Union

FAO	Food and Agricultural Organisation
FAR	Stakeholder from the Farming Sector
FGD	Focus Group Discussion
FIFA	Fédération Internationale de Football Association
FOR	Stakeholder from the Forestry Sector
GRI	the Garden Route Initiative
GRNP	Garden Route National Park
GWP	Global Water Partnership
I&AP	Interested and / or Affected Parties
i.e.	Latin: id est; 'that is' (to say)
ICMA	Inkomati Catchment Management Agency
ID	Identity Documents
IDP	Integrated Development Planning / Integrated Development Plan
ILÖK	Institut für Landschaftsökologie (Institute of Landscape Ecology, Münster)
INT	Semistructured Interview
INT IF	Informal Interview
IPSWaT	International Postgraduate Studies in Water Technologies
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
KCMF	Knysna Catchment Management Forum
KEF	Knysna Environmental Forum
KNY	Knysna
LM	local Municipality
MA	Millennium Ecosystem Assessment
MIG	Municipal Infrastructure Grant
Ml / day	Megalitre per day

MUN	Municipality
n.d.	no date
n.p.	no page
NEMA	National Environmental Management Act
NGO	Non-Governmental Organisation
NMMU	Nelson Mandela Metropolitan University
NRM	Natural resources management
MTO	Mountain to Ocean, now Cape Pine, South African Wood Company
NWA	National Water Act
NWRS	National Water Resources Strategy
O&M	Operation and Maintenance
PDMC	Provincial Disaster Management Centre
PES	Payment for Ecosystem Services
Petro SA	South Africa's National Oil Company
PO	Participant Observation
PO CO	Participant Observation as Complete Observer
PO OP	Participant Observation as Observer as Participant
RBIG	Regional Bulk Infrastructure Grant
RO	Reverses Osmosis Plant
SAM	Strategic Adaptive Management
SANBI	South African National Biodiversity Institute
SANBI ISP	South African National Biodiversity Institute Invasive Species Programme
SANParks	South Africa National Parks
SANRAL	South African National Roads Agency Limited
SAPS	South African Police Service
SED	Sedgefield

SPI	Standardised Precipitation Index
SRU	NMMU’s Sustainability Research Unit
SRVA	Sedgefield Ratepayers and Voters Association
STS	Science and Technology Studies
SWOT	Strengths, Weaknesses, Opportunities and Threats
TB	Tuberculosis
TR	Transdisciplinary Research
WARMS	Water Authorisation and Registration Management System
WC	Western Cape (Province in South Africa)
WESSA	the Wildlife and Environment Society of South Africa
WfW	Working for Water (South African Extended Public Works Programme)
WI	Wuppertal Institute for Climate, Environment and Energy
WLCMF	Wilderness Lakes Catchment Management Forum
WMA	Water Management Areas
WMI	Water Management Institutions
WRC	Water Research Commission
WRM	Water resources management
WUA	Water User Associations
ZEF	Zentrum für Entwicklungsforschung, (Center for Development Research, Bonn)

SUMMARY

This study aims at advancing the scientific field of boundary work in the context of complex and contested water resources management problems with a focus on developing countries[2]. Water resources management is often challenged by distinct barriers between multiple stakeholders from policy, science and society, based on diverging concepts, powers, interests, and responsibilities in local water resources management. These boundaries hamper integrated approaches for joint decision-making, management and research. It is one of the most challenging but most important requirements for the development of integrated solutions for holistic and sustainable water resources management to first acknowledge and second deal with and try to dissolve these barriers between different stakeholders.

The science of boundary work specifically focuses on analysing and addressing social, organisational, cultural or political barriers between different actors that hamper knowledge transfer, communication and collaborative decision-making and action. A framework to analyse boundaries and boundary work processes in complex and contested problems of natural resources management has been developed by Mollinga (Mollinga 2008a, 2008b, 2010a). He states that fruitful cooperation across these boundaries requires the active development of shared 'boundary concepts' of actors, the development and application of tuned 'boundary objects', as tools that support collaborative decision-making and action, and the shaping of 'boundary settings', as framework conditions that can support or hamper collaboration. This study aims to investigate, how this boundary work framework can add to systematically as-

[2] The conventional distinction between 'developing countries' and 'developed countries' reflects a biased thinking in perceiving the world. Further, there is no unique definition of 'development', and what implies 'development' is very different for different contexts. Whereas conventional thinking associates 'growth' with 'development', the researcher associates '(global) transformations towards sustainable societies' with the term 'development', which partially rather requires sufficiency than growth, and is required anywhere in the world. However, due the lack of an appropriate and impartial terminology for differentiation of nations, depending on their specific local, political, social, economic and environmental properties and challenges, the patter will be used in this study, being aware of the respective limitations.

sess and approach complex and conflictive problems of local water resources management and support improved collaboration of conflicting stakeholders.

Chapter 1 provides background information on the study, introduces into the research objectives, scientific research questions, research approach and the structure of the thesis.

Chapter 2 covers conceptual research on boundary work and the boundary work framework, (Mollinga 2008a, 2008b, 2010a). It develops extensions to the framework, by adapting it to the specific needs of water resources management and research, with a focus on developing countries. The amendments are generated by reflecting leading approaches in the field of natural resources management (i.e. Integrated Water Resources Management, Adaptive Management, the Ecosystem Approach) in the view of the framework. This is done by analysing how each approach addresses, defines or applies boundary concepts, objects and settings in water or natural resources management. Given the political dimension of water resources management, insights from a water governance perspective are further merged into the view of the framework. Based on the analyses and following Mollinga's rationale, the chapter clusters and proposes amended 'boundary concepts' to communicate about problems in water resources management, 'boundary objects' to facilitate communication and collaborative action and 'boundary settings' to understand limitations and limits to change towards sustainable water resources management. By further reflecting findings from transdisciplinary research through a boundary work perspective, the chapter concludes with a proposal, how to design boundary work processes from scratch. The conceptual research in Chapter 2 is purely based on intensive literature research of primary and secondary sources.

Chapter 3 contains a South African case study that aims at analysing reasons and obstacles for collaborative local water resources management in a tangible case through a boundary work perspective. South Africa is conceptually leading with regard to its sustainability oriented water policy and legislation and public participation towards equitable, sustainable and efficient water resources management is a high priority. Nevertheless, practical implementation faces enormous challenges, based on the extreme socio-economic and cultur-

al divides, as well as the major lack of capacities, that characterise the young democracy. The real-life situation under normal management circumstances proofed to be driven by strong fragmentation of stakeholders and management approaches, based on diverging concepts on problem definitions, management objectives and management principles. A second phenomenon that in general marked local water resources management, was the exclusion of the poor, the so called previously disadvantaged communities, from local water resources management. However, integration of specifically this stakeholder group was of utmost political importance in post-apartheid South Africa and also required by national legislation and policy. Exclusion could be assigned to the very high levels of inequality, poverty and unemployment that characterised not only the situation at the study site, but South Africa in general. It was further found that collaboration across stakeholders was inherently different, and had considerably improved under severe water stress, as experienced during the drought that affected the research area between 2009 – 2011. Decisions taken during emergency in terms of infrastructure developments, however, now constitute challenges for sustainable water supply in a mid- to long-term perspective. The purely qualitative research of this chapter covered data collection through interviews, group discussions, observations and collection of formal and informal background documentation. Data analysis was conducted with the support of software for qualitative data analysis, through deductive and inductive coding procedures, by applying methods from grounded theory.

Chapter 4 covers grounded analytical developments to the boundary work framework based on the findings of applying it in the empirical (and instrumental) case study. It was found that the framework was suitable to develop its analytical strength only after phenomena that characterised collaborative local water resources management, in terms of fragmentation, exclusion, and different dynamics of collaboration under pressure, had been identified. After developing an analytical superstructure in terms of abstracted phenomena, the framework enabled to understand reasons and obstacles for collaborative water resources management in terms of concepts, objects and settings. Diverging concepts mainly played out in three categories: concepts on problem statements, management objectives and management principles. It was found that a principal requirement for effective communication and collaboration between stakeholders and relating to all these three categories was the need to develop a shared understanding of the meaning of commonly used 'words', thus the development of shared boundary concepts on 'terminology'. Settings of importance in the local case played out in five categories, namely external, organisational, individual, natural and technical settings. Grounded development of the framework further suggested changing the notion of boundary objects and to (newly) categorise them into: bridging agents, participatory processes, mechanisms and products. The analysis for this chapter was based on deductive and inductive coding procedures of empirical data by applying methods from grounded theory.

Chapter 5 provides final conclusions and recommendations for future research. South Africa's Gini coefficient is among the highest rankings worldwide and the nation is generally characterised by extreme socio-economic dichotomies and inequalities. This reality questioned integrated and sustainable water resources management, by touching matters of fulfilment of the basic needs of a great majority versus an explicit and high emphasis on the protection of water and other natural resources. It further questioned the 'equal chances' to participate in and shape decision making for everyone, as required by the national water resources management framework. Future research is needed that specifically addresses questions of sustainable resources management in (similar) developmental contexts, characterised by extreme inequalities, in the following fields:

Conceptual research is needed to analyse concrete contributions of the emerging field of boundary work science to the scientific fields of sustainability science, transition research and transition management. This further requires a stringent focus on developmental contexts and contexts characterised by extreme socio-economic inequalities.

To advance the scientific field of boundary work, further empirical case studies are needed at different scales, with different levels of interaction with and between stakeholders in varying (developmental) contexts. They should, as done in this intensive small-scale research, either focus on an in-depth study of a local case, or alternatively, if implemented at large scale, focus on design, im-

plementation and analysis of processes of transformative change, based on transdisciplinary research and adaptive management approaches. Again, for both types of studies there is an inherent need to focus future research on developmental contexts and on contexts characterised by extreme socio-economic dichotomies.

The specific local situation at the study site requires the development of true boundary concepts on the problems to be addressed, the objectives to be achieved and the management principles to be applied. Further, there exists the need for development of proper functioning boundary objects, in terms of bridging agents, processes, mechanisms and products that are specifically designed to acknowledge and redress poverty, unemployment and the distinct inequalities. Facilitating such a process asks for a legitimate bridging agent, who could moderate discussions and decision-making processes.

Future Research is further needed to translate and communicate the findings of this study through tailor – made boundary objects based on the core principle that science must be accessible without barriers to everyone (intellectually, legally and technically), also in developmental contexts, and contexts characterised by extreme inequalities.

1 INTRODUCTION

1.1 Background of the Study

It is a common understanding that water problems in many regions of the world are rather based on poor water governance and management practice than on actual water scarcity. Especially in the developing world, the water sector is often characterised by organisational fragmentation, inadequate institutional and administrative structures with unclear and sometimes overlapping roles and responsibilities, inadequate regulatory mechanisms and, finally, scarce resources, in terms of qualified staff and financing mechanisms.[3] In addition, the range of conflicting actors or stakeholders with no or low interest in cooperation is specifically high in water resources management, as water is a highly politicised and contested natural resource. Further, water systems are complex systems, characterized by uncertainty, and knowledge on system behaviour is limited. This holds especially true for the developing world, where lack of data and information often add to the general governance and management challenges. The above-mentioned deficiencies ask for a holistic management approach that incorporates knowledge generation and integrates policy, science and civil society into problem solving.

Distinct social, cultural, political or knowledge barriers in the field of water resources management exist between political and scientific actors, public utility managers and civil society or between representatives from different sectors such as water, environment, industry and agriculture with their diverging

---

[3] The conventional distinction between ‘developing countries‘ and ‘developed countries‘ reflects a biased thinking in perceiving the world. Further, there is no unique definition of ‘development’, and what implies 'development' is very different for different contexts. Whereas conventional thinking associates 'growth' with 'development', the researcher associates '(global) transformations towards sustainable societies' with the term 'development', which partially rather requires sufficiency than growth, and is required anywhere in the world. However, due the lack of an appropriate and impartial terminology for differentiation of nations, depending on their specific local, political, social, economic and environmental properties and challenges, the patter will be used in this study, being aware of the respective limitations.

powers, interests, and responsibilities. In the context of the developing world, more actors add to this already complex situation: a variety of international organisations, ranging from multilateral funding organisations to state-driven donor organisations and non-governmental organisations with their individual objectives, motives and agendas. It is one of the most challenging but most important requirements for the development of solutions for holistic and sustainable water resources management to first acknowledge and second deal with and try to dissolve the barriers between the different stakeholders.

Boundary work has emerged as field of science that supports to understand and address these societal boundaries for collaboration. It implies analysing and actively addressing barriers between stakeholders that hamper collaborative decision-making and action. Originally stemming from the Social Study of Science, research on boundary work is now more and more also situated within Science and Technology Studies (STS) and the emerging field of Sustainability Science. This is based on the acknowledgement that societal transitions towards sustainability in form of holistic or otherwise comprehensive decision-making and planning processes require active integration of multiple stakeholders, by acknowledging their diverse perspectives, positions, powers and politics. Collaborative decision-making is often hindered by cognitive, institutional, cultural or other barriers across stakeholders, and it is recognized that these barriers do not dissolve without actively addressing them through concentrated efforts (Cash et al. 2003, Mollinga 2010a). To be able to effectively dissolve these hindrances for collaboration, it is a basic requirement to first understand, how they are constituted and manifested.

This research aims at advancing the scientific field of boundary work in the context of complex and contested water resources management problems with a focus on developing countries.

1.2 Research Objectives, Scientific Research Questions and Research Approach

A framework to analyse boundaries and boundary work processes in complex and contested problems of natural resources management has been developed by Mollinga (Mollinga 2008a, 2008b, 2010a). He states that fruitful cooperation requires the active development of shared 'boundary concepts' of actors, the development and application of tuned 'boundary objects', as tools that support collaborative decision-making and action, and the shaping of 'boundary settings', as framework conditions that can support or hamper collaboration. The new framework has so far only been applied to very limited extents in conceptual and empirical research (see e.g. Hornidge 2011, Hornidge et al. 2013, Leidel et al. 214, Mattor et al. 2014, Oberkircher et al. 2011) This study aims to investigate, how the boundary work framework as developed by Mollinga can add to systematically assess and approach complex and conflictive problems of local water resources management.

The objectives of the study play out on a conceptual as well as on an empirical level: Conceptually, it shall be reflected, how the boundary work framework (Mollinga 2008a, 2008b, 2010a) can be used to analyse, structure and design boundary work processes in complex and contested water resources management problems, with a contextual focus on developing countries. At an empirical level, it shall be investigated what supports or hampers collaborative water resources management in a real-life situation. Therefore, a case study is conducted at the Garden Route region, South Africa. The local case is assessed by applying a boundary work perspective as model of thought. Analysing boundary concepts, objects and settings that influenced real-life water management and decision-making at local level is expected to provide an analytical basis to help gearing water planning and management towards a more collaborative and sustainable approach in future. The case study is both, intrinsic, as well as instrumental: intrinsic, as it provides inherent insights into reasons and obstacle for collaboration in a 'real-life' management situation, and instrumental, as it serves to test and further extend the boundary work framework as contribution to sustainability science, transition research and transition management.

Scientific analysis on how the ‚Boundary Work Framework' (Mollinga 2008a, 2008b, 2010a) can support a structured analysis of complex and contested water resources management problems in developing countries by:

I) Conceptually adapting the framework to water resources management and research in developing countries;
II) Applying the amended framework as model of thought in an empirical and instrumental case study to analyse reasons and obstacles for collaborative local water resources management;
III) Analysing the local case as medium to reflect upon suitability of the framework in its current state;
IV) Developing the framework further, based on the empirical insights.

Box 1 Overall objectives of this research

The research objectives were translated into scientific research questions as follows:

Main research question

How can the boundary work framework (Mollinga 2008a, 2008b, 2010a) be used to analyse, structure and approach boundary work processes in complex and contested problems of local water resources management?

Sub-questions I: Conceptual foundation – adapting the framework

- How can principles, methods and tools provided by leading approaches in natural resources management and research (i.e. Integrated Water Resources Management, Adaptive Management, the Ecosystem Approach and Transdisciplinary Research) support the analysis and development of boundary concepts, objects and settings in water resources management and research?
- How can boundary work processes be designed and initiated from scratch in complex and contested problems of water resources management?

Sub-questions II: The case study – applying the framework

- How do modes of collaboration in local water resources management – hence processes of boundary work – function in a local context (here in selected river catchments – the Swartvlei and Knysna Catchments – at the Garden Route region, South Africa)? What hampers or supports collaborative decision making and action, in terms of boundary concepts, objects and settings?
- How does the current real-life management approach as encountered at the study site play into striving for equity and sustainability – two core principles of South African Water Resources Management?
- How could collaboration be improved, towards a more equitable and sustainable approach of water resources management?

Sub-question III: Conceptual findings – extending the framework

- How can the insights as gained through the empirical and instrumental case study contribute to developing the framework further to support understanding, structuring, communicating and approaching complex water problems through a boundary work perspective?

Research approach, data collection and analysis: Data was collected and analysed in an iterative process between 2010 and 2015: The conceptual research (sub-questions I) is based on intensive literature research of primary and secondary sources. The empirical case study (sub-questions II) covers intensive field research, and data collection is purely based on a set of qualitative methods. Data was collected in three field research periods of altogether fourteen months. Methods included the implementation of semi-structured interviews with experts as well as lay-persons, implementation of focus group discussions, participant observation in public participation processes and constructive events around water and sustainable development and the implementation of two feed-back workshops at the end of field research to present and discuss the preliminary findings with local stakeholders. Data collection further comprised the assembly and analysis of multiple forms of formal and informal secondary data that documented past processes, priorities and dynamics of decision making around water resources management and sustainable development. Interviews and group discussions were mostly recorded and relevant parts transcribed. Data analysis was conducted with the help of a software for qualitative data analysis (atlas.ti), by applying inductive and deductive coding procedures to selected materials, following approaches from 'grounded theory' (Charmaz 2006, Glaser and Strauss 2009). The generic empirical research methodology is in detail explained in Chapter 3.3. The insights from the case study – as developed through deductive and inductive coding – further serve the analytical development of the boundary work framework (sub-questions III).

Conceptual Study (Sub-questions I)

- Intensive literature research (primary and secondary literature).

Empirical Study (Sub-questions II)

- Qualitative data collection: primary data collection through formal and informal interviews (95), group discussions (11), workshops (2) and observations (33); secondary data collection of formal and informal background documentation.
- Documentation of interviews, group discussions and workshops through audio files, partial transcriptions and field notes.
- Data Analysis: with the support of atlas.ti (software for qualitative data analysis) through deductive and inductive coding procedures, applying methods from grounded theory.

Conceptual Advancements (Sub-questions III)

- Data Analysis: with atlas.ti through deductive and inductive coding procedures, applying methods from grounded theory.

Box 2 Methods for data collection and analysis

1.3 Structure of the Book

Following the objectives and research questions, three lines of research have developed, that iteratively influenced each other, but also remained distinct in their nature. They are reflected in this thesis in three separate chapters. Each chapter contains both: generic instrumental input to answer the main research question, but also an intrinsic and closed analysis in itself. Thus, each chapter starts with a reminder of the respective sub-questions, and finishes with conclusions for this specific part of research. As conceptual and empirical research developed through an iterative process, a certain extent of iteration in the discussion and presentation of findings is an intrinsic element of the thesis.

In Chapter 2, extensions to the boundary work framework are developed, by adapting it to the specific needs of water resources management and research in the developing world. The amendments are generated by reflecting leading approaches in the field of natural resources management (i.e. Integrated Water Resources Management (GWP 2000), Adaptive Management (Medema and Jeffrey 2005, Medema et al. 2008, Pahl-Wostl et al. 2007) and the Ecosystem Approach as developed under the Convention on Biological Diversity (CBD) (United Nations 1992) in the view of the framework. This is done by analysing how each approach addresses, defines or applies boundary concepts, objects and settings in natural and water resources management. Further, insights from a water governance perspective are merged into the perspective, as well as findings from Transdisciplinary Research (Lawrence and Després 2004, Mollinga 2008a, Pohl 2005, Pohl and Hirsch Hadorn 2007). The chapter further covers a generic proposal, how to design boundary work processes for collaborative decision-making and action from scratch and concludes with a summary of findings and further research needs.

In Chapter 3, an empirical case study covers the analysis of reasons and obstacles for collaborative water resources management at the Garden Route region, South Africa, by focusing on selected river catchments within Knysna Municipality, Eden District, Province of the Western Cape. It applies boundary work thinking, by discussing structural phenomena that reveal reasons or barriers for collaborative decision-making and action in local water resources management. It analyses core concepts and settings of actors, that influence and hamper collaborative water resources management, and assesses formally and informally developed boundary objects for integrated decision making. Analysing boundary concepts, objects and settings that influenced real-life water management and decision-making at local level is expected to provide an analytical basis to help gearing water planning and management towards a more collaborative and sustainable approach in future. Water resources planning and management in South Africa is according to national policy and legislation based on the core principles of 'equity' and 'sustainability'. The research further discovers how the current 'real-life management approach' as encountered at the research site works towards – or against – these core principles.

The motivation of the case study is both, intrinsic, as well as instrumental, and thus serves two purposes: apart from revealing local modes of collaboration in water resources management, as described above, it is instrumentally used to develop boundary work thinking, and specifically the boundary work framework further. The case study focuses on an in-depth analysis of the local situation; it is neither experimental, nor was it intended to apply and further develop the proposed methodology to design and facilitate boundary work from scratch, as outlined in Chapter 2. It purely aims to understand, how boundaries for collaborative water resources management are constituted and manifested in the local context. Nevertheless, the in-depth analysis to some extent also allowed insights into the appropriateness of the proposed methodology for boundary work. Based on the insights and challenges faced by applying the framework in the empirical case study, empirically grounded extensions to the framework are elaborated and discussed in Chapter 4. The chapter concludes with a (new) proposal for an amended boundary work framework.

Chapter 5 contains final conclusions and further includes an outlook on future research needs.

2 CONCEPTUAL RESEARCH: BOUNDARY WORK AND WATER RESOURCES – TOWARDS IMPROVED MANAGEMENT AND RESEARCH PRACTICE?[4]

Sub-questions I: Conceptual foundation – adapting the framework

How can principles, methods and tools provided by leading approaches in natural resources management and research (i.e. Integrated Water Resources Management, Adaptive Management, the Ecosystem Approach and Transdisciplinary Research) support the analysis and development of boundary concepts, objects and settings in water resources management and research?

How can boundary work processes be designed and initiated from scratch in complex and contested problems of water resources management?

Box 3 Sub-questions I: Conceptual foundation – adapting the framework

2.1 Introduction and Outline

Water is the basic resource for life and ecosystem health, which leads to competition in water use, not only between humans and nature, but also between humans of different interest groups. Diverse approaches have been developed for implementing sustainable water resources management and research and a common feature required by both, science and policy, is the acknowledged need to apply a 'holistic' or 'comprehensive' perspective to natural resources management, to allow integrating multiple and often conflicting perspectives of stakeholders. Three currently leading approaches in the field are subject of the analysis presented in this study: Integrated Water Resources Management (IWRM), Adaptive Management (AM) and the Ecosystem Approach (EA). Defi-

[4] This chapter has been published in an earlier version under the Center for Development Research's (ZEF) Working Paper Series. (Dörendahl 2013)

nitions of these approaches widely vary and while each approach provides important – rather complementing than contradicting – principles and methods for holistic management of water and other natural resources, coherence is not given. Complexity of principles, methods and tools makes it difficult to find a way through the jumble of options when trying to approach complex and contested water management problems in a practical manner.

To achieve sustainable water resources management, an approach is required that does not only foster reduction of complexity while focusing on developing practical solutions for contested water issues, but also focuses on knowledge generation to reduce uncertainties and to facilitate mediation between different, probably conflicting stakeholders. This can be facilitated through the process mode of Transdisciplinary Research (TR). TR provides a methodology how to define, structure and approach complex and contested problems that require knowledge generation. It integrates multiple actors with their diverse interests and puts a strong focus on action-orientation and concrete problem solving.

The success of the above mentioned approaches depends on effective collaboration and communication between (often conflicting) stakeholders. Effective collaboration can be facilitated through the emerging scientific field of 'boundary work'. The literature on boundary work stems from the Social Study of Science, is also complemented by insights from organisational and management studies, and is currently emerging into the scientific fields of Science and Technology Studies (STS) and sustainability science. All streams lack a uniform definition of boundary work, but encompass a variety of complementing perspectives. In general terms, boundary work focuses on analysing cognitive, cultural, institutional or organisational boundaries or knowledge divides between stakeholders and ideally supports bridging them by adequate knowledge production: problem specific knowledge and information are generated, distributed and communicated through different tools and products, or bridging agents – so called 'boundary objects'.

A framework to systematise boundary work in complex and contested problems of natural resources management has been developed by Mollinga (2008a, 2008b, 2010a). It supports the structured reflection and approach of complex problems by developing ‘boundary concepts’ – the language to communicate a problem across stakeholders, ‘boundary objects' – the tools to approach and balance contested issues, and ‘boundary settings’ – the framework conditions that shape the problem. Or else, it supports the ‘rationale organisation of dissent’ in complex and contested resources management problems (see also Mollinga, 2008a). The framework just started to spark thinking in current research (Hornidge 2011, Hornidge et al. 2013, Leidel et al. 214, Mattor et al. 2014, Oberkircher et al. 2011), and experiences in working with this new conceptual model are still very scarce. Research is required to systematically apply the framework in conceptual as well as empirical studies, and further, to adapt it to other fields of science.

Given the importance of water as a highly contested natural resource, this chapter attempts to evolve the boundary work framework to the specific needs of water resources management and research. A specific focus is put on the assessment of characteristics of boundary work in developing countries, under acknowledgment of concrete but complex challenges for transformational change and sustainable development in different developmental contexts.

In Chapter 2.2 it will be reflected, which boundaries characterise water resources management and research, with an additional focus on developing countries. Chapter 2.3 includes an overview on the science of boundary work and the boundary work framework. In Chapter 2.4, three currently leading approaches in natural resources management, i.e. IWRM, AM, EA are analysed in detail through the perspective of the framework. The framework is further systematically extended in Chapter 2.5 by merging insights from the highly important – but often still neglected – field of water governance. These analyses serve to derive conceptual modifications to the framework regarding the notion and classification of boundary concepts, objects and settings for collaborative and sustainable water resources management, which are discussed in Chapter 2.6. Based on transdisciplinary research principles a procedure is proposed in Chapter 2.7 that supports the design of boundary work processes in complex and contested water resources management problems ‘from scratch'. This is concluded in Chapter 2.8 by a summary of findings and an outline of further research requirements.

2.2 Boundaries and Water Resources

Water resources management in real-life is often challenged by distinct barriers between multiple stakeholders, based on diverging concepts and settings, which hamper integrated approaches for joint decision-making and management. Fruitful collaboration requires effective 'boundary crossing', which does not happen without concrete efforts. To effectively address these boundaries, it is required to analyse and understand how they are constituted. The following chapter provides an assessment of boundaries that are of specific importance in water resources management and research. An additional focus lies on the reflection of boundaries of specific relevance in the developing world, where water problems, such as water availability, allocation and / or quality, constitute serious obstacles for development in general. Especially in these contexts, water is a highly contested and politicised natural resource.

Water resources management is characterised by societal barriers between multiple actors, which need to be dissolved to allow for integrated management and research in a holistic manner. Water management and research has to deal with **boundaries of scale**: catchments do not confine themselves to administrative borders of states or nations. Promoting management and research that is oriented at catchment boundaries may ask for approaches that cover two to multiple nations in need to coordinate efforts. Here, barriers between political systems, cultures and power-relationships shape the arena. If a catchment fully lies within national boundaries, the approach may still have to deal with different States, Provinces and Districts and their respective administrative bodies and interests.

Within a nation, cultural, cognitive or institutional boundaries further exist **within and also between the different actor-clusters of government, civil-society or non-state actors and science** that all actively involve in water issues of all kinds (see also Chapter 2.5 and following Turton et al. 2007), which will be explained in the following:

The action-cluster of government is characterised by a vertical structure, reflecting governmental bodies on national, regional and local scale that may or may not cooperate well with each other. On a horizontal structure, barriers exist between public agencies on the same scale of government, but of different sectors. Many sectors apart from water are involved in water management and use. This covers e.g. environment, agriculture, industry, health and energy. Ministries or departments of the same level of government but from different sectors may not be willing to cooperate with each other on water issues.

Society in this definition encompasses civil society[5] – here understood as non-governmental organisations, private entities, community based organisations and households and individuals. Each group or organisation of civil society has its own perceptions, values, cultures, objectives and norms. Barriers in the water sector between interest groups of civil society may be strong, as e.g. be experienced between water utilities' revenue collection department and private (poor) households, which may have little ability and / or willingness to pay water tariffs.

Within science multiple barriers exist between disciplines and sub-disciplines: The scientific world is organised in disciplines (e.g. biology, geology, chemistry, economics, history etc.), structured along the three categories of natural science, social science and life science.[6] Within these disciplines further sub-division takes place into different fields of specialisation, e.g. botany, zoology, hydrogeology, soil science etc. Specialisation goes on and on, and sub-sequent specialisation can e.g. cover subjects like 'irrigation practice in the sub-tropics' and others. Interdisciplinarity now refers to 'working across barriers of different disciplines', which according to the categorisation above can occur on different levels: barriers can exist between a) the three main categories, (e.g. social scientists and natural scientists), b) different disciplines within these categories (e.g. geologists and botanists) and c) different fields of specialisation

[5] While society in a general interpretation actually includes science and government, it is here used in a simplified understanding, referring to 'non-state' and 'non-scientific' actors.

[6] Though not all disciplines can be fitted well into that scheme (e.g. law or mathematics), this structure has evolved historically and has not been changed so far.

within these disciplines (e.g. geoecologist and biogeochemist) (following Mollinga 2008a).

While specific barriers are encountered within each actor-cluster, major boundaries also exist between the clusters, thus between government and science, government and society and science and society. Government ideally should base governance on the needs of the society. In a democratic system, society in turn critically reflects government action and legitimates or denies it. Science, ideally, supports political decision-making by providing salient, credible and legitimate knowledge (Cash et al. 2003). These barriers – or interfaces – are reflected by Turton et al. (2007: 17) and shall, due to their importance for this study, be cited in full length:

'The Government-Society interface determines the needs and requirements of society, the legitimacy of the political process, and the permeability of government to new ideas from civil society and the corporate world. The interface also represents the degree to which the needs of society are satisfied by government;

The Government-Science interface determines the extent to which science and technology form the basis of the political economy, and the extent to which scientific knowledge informs the decision-making processes that are a core function and output of the government actor-cluster. Government facilitates and enables the scientific processes through policy initiatives, resource allocations and overall strategic direction. This interface is critical as it has major implications for social stability and economic growth, making it a key issue for effective governance in the developing countries with fledgling democracies; and

The Science-Society interface can be thought of as science in the service of society, consisting of a number of elements, including the way that scientific knowledge is diffused into society. In a developed country with a mature democracy this is visible as the technology-base of the economy. In developing countries with fledgling democracies, this is reflected in the effectiveness with which the science and technology-base is harmonised with the overall needs of society, and becomes a key determining factor in the success of the emerging economy as it overcomes historic and structural comparative disadvantages.'

In the developing world another actor-cluster needs to be added: the **international (donor) organisations** with their individual underlying schools of thought and interests. While ideally they may be 'drivers of change', through facilitating knowledge-generation and transfer as well as finance, they can also considerably disturb the local system by intervening into local political affairs or by non-harmonised action within the donor actor – cluster. Interference or cooperation of international governmental, non-governmental or scientific organisations exists between all before mentioned clusters in the local context: Governmental agencies cooperate with governments, international universities involve with local universities, private companies involve with government and science actors, non-governmental organisations (NGO) with science and society etc.

When approaching complex and contested water problems it is of fundamental importance to reveal the problem- and context-specific core barriers within and also between the above mentioned clusters in the local setting and to further classify them into barriers that may be weakened or dissolved through concentrated efforts and barriers that need to be accepted as unchangeable within a given time-frame and with limited resources.

2.3 The Boundary Work Framework

The notion of boundaries has been studied in various fields of the Social Sciences (Lamont and Molnár 2002), further also in organisational and management studies and more recently also in STS and Sustainability Science. The science of boundary work focuses on analysing and addressing social, organisational, cultural or political barriers between different actors that hamper knowledge transfer, communication and collaborative decision-making and action. Originally, research in boundary work formed part of the 'Sociology of Knowledge' (Kuklick 1983) and follows a social constructivist perspective. Whereas initially the concept was developed to assess boundaries between scientific and non-scientific actors (Evans 2005, Gieryn 1983) it was further applied to analyse science-policy interactions and dependencies (Hoppe 2005). Science-policy relationships have further in detail been reflected in principal – agent theory (see e.g. Braun and Guston 2003).

Recent research in boundary work mostly covers retrospective and empirical analyses of specific boundary arrangements that helped to dissolve barriers between actors. This covers the analysis of developments of 'boundary objects' or 'boundary organisations' as tools for boundary work (Agrawala et al. 2001, Cash 2001, Cheng et al. 2015, Guston 2001, Keating 2001, Miller 2001, Star and Griesemer 1998, Sternlieb et al. 2013, White et al. 2008). Conceptual research on boundary work is scarce, but more and more situated within the field of Sustainability Science. Recent conceptual studies e.g. focus on the analysis of knowledge transfer and use across boundaries (Cash et al. 2002, Cash et al. 2003, Clark et al. 2010).

A framework to conceptualise and operationalize boundary work for complex and contested problems of natural resources management (NRM) has been developed by Mollinga (Mollinga 2008a, 2008b, 2010a). Mollinga defines 'framework' as *'a conceptual construct with limited theoretical (explanatory) ambition as such, but which is mainly oriented towards bringing together different pieces of knowledge (…) in a 'workable' manner.'* (Mollinga, 2008: 32). The boundary work framework bases the analysis of boundary work processes on three elements: boundary concepts, boundary objects and boundary settings. Mollinga argues that *'integration as form of boundary crossing does not happen automatically but requires concerted effort. The framework (…) suggests that effective inter- and transdisciplinary analysis and action requires three types of work: 1. The development of suitable boundary concepts that allow thinking, that is, conceptual communication, about the multidimensionality of NRM issues. 2. The configuration of adequate boundary objects as devices and methods that allow acting in situations of incomplete knowledge, nonlinearity, and divergent interests. 3. The shaping of conducive boundary settings in which these concepts, devices, and methods can be fruitfully developed and effectively put to work.'* (Mollinga 2010a: 4). Mollinga's notion of boundary concepts, objects and settings as key elements of boundary work processes, shall be explained in further detail:

Boundary concepts are referred to as the analytical work for understanding a problem, as well as the development of a commonly shared terminology for all actors, to foster communication and cooperation across sectors, disciplines and between professionals and lay-persons. The framework defines boundary concepts as *'words that function as concepts in different disciplines or perspectives, refer to the same object, phenomenon, process, or quality of these, but carry (sometimes very) different meanings in those different disciplines or perspectives. In other words, they are different abstractions from the same 'thing'* (Mollinga 2010a: 4).[7] Boundary concepts in local water resources management can thus be captured by 'words' or 'terminology' of actors, associating different meanings to similar phrasing. Depending on the different academic or working background and the cultural context a person is settled in, different concepts are reflected by using the same wording. An example can be given through the term of 'water control', which contains considerably different notions depending on the background of the people using it. While e.g. engineers will primarily associate 'technical control' through infrastructure measures with 'water control', e.g. flood control through dams, representatives from public administrative bodies may rather interpret the term in the context of 'organisational control'. To political scientists it has the connotation of 'political control' of water resources. Different notions according to different academic disciplines are summarised in Table 1:

[7] Mollinga (2010b) further elaborates on the notion of boundary concepts in a concrete South Asian context.

Table 1 Three dimensions of water control (Mollinga 2010a: 5)

Dimension	Association/meaning	Disciplines	Example references
Technical control	Guiding-manipulating-mastering of physical processes	(Civil) engineering, soil mechanics, hydraulics, hydrology, agronomy, meteorology, agro-ecology	Plusquellec et al. 1994: 35
Organisational control	Commanding-managing of people's behaviour	Management science, extension science, public administration, organisation sociology	Hunt 1990: 144, Huppert 1989: 35, Lowdermilk 1990: 155
Socio-economic and political control	Domination of people('s labour) Regulation of social processes	Political economy, economics, rural sociology, political science, social and cultural anthropology, gender studies, agrarian history	Stone 1984: 202, Boyce 1987: 198−199, 229, 233, Enge and Whiteford 1989: 5−7

Boundary concepts support the development of a common understanding by associating similar meanings to the same words. This is understood as basis to enable communication between scientists from different disciplines, politicians and other stakeholders that are involved in inter- and transdisciplinary research.

Boundary objects are considered the 'instrumental work for action'. They generally refer to all types of devices, methods, products and tools that facilitate communication between different actors about issues under dispute. One definition of boundary objects is as follows: they are scientific objects '*which both inhabit several intersecting social worlds (…)* and *satisfy the informational requirements of each of them. (…) Boundary objects are objects which are both* *plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. These objects may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds'* (Star and Griesemer 1989: 393). Although considered as important tools to facilitate communication and cooperation across boundaries, the concept of boundary objects still remains vague.

A classification of boundary objects is presented in Mollinga's framework. It has been developed with a focus on scientific knowledge production to support decision making in the field of complex and contested problems in natural resources management in transdisciplinary research projects. Mollinga distinguishes three types of boundary objects, depending on their route of development: the analytical route, the assessment route and the participatory route. In the analytical route modelling of complex system's behaviour is used to develop extensive decision support systems (DSS) as one example of a boundary object. These shall support decision making under uncertainty. However, in short the success story of DSS especially for the developing world is described as limited, as *'many modelling and decision support system development efforts are science driven not user driven'* (Mollinga 2010a: 5), and would miss to reflect the local cultural and political realities. In the assessment route, frameworks, matrices and flowcharts are used to communicate a problem and potential solutions – a path that would be favoured by practitioners. Foreign organizations in the context of international development cooperation would often follow a participatory route as boundary object, for which an ample range of well-developed methodologies and experiences exist. Also Mollinga's classification of boundary objects however remains vague and difficult to grasp in practical terms and needs further development. The following chapters are an attempt to fill that gap and elaborate and discuss possible extensions and concretion.

Boundary settings refer to the structural conditions that shape the problem and the project. Mollinga puts a focus on transdisciplinary research projects. The **internal boundary settings** relate to the dynamics and framework conditions in the direct context of a research project: how is the research project organised, how is research work distributed and knowledge shared among research partners? **External boundary settings** refer to the wider framework conditions in which the project is situated, e.g. the political regime, legal regulations, power divisions, underfunded governmental bodies, corruption, availability of skilled staff, staff continuity in public organisations etc. By designing suitable boundary objects to approach a problem, the internal settings may moderately be influenced, however, the external settings are considered as almost unchangeable in the time frame of a research project.

Whereas the general classification of boundary work processes into boundary concepts of actors, boundary objects and boundary settings may provide an appropriate analytical categorization to assess and classify reasons and obstacles for collaborative resources management, the proposed subcategories need further reflection to be of practical use and analytical applicability. The general classification into concepts, objects and settings will be used in the following, to systematically reflect upon and merge prominent principles and elements of leading approaches for water and natural resources management. This shall serve to reflect upon generic boundary concepts for water resources management and research, a classification and overview on boundary objects to facilitate collaboration and the reflection of boundary settings that support or limit potential change. This will be done with a focus on the specifics and needs of developing countries.

2.4 Natural Resources Management through a Boundary Work Perspective

Various approaches have been developed to address water and other natural resources management problems worldwide, based on different schools of thought. While some put a stronger focus on research and knowledge generation in a process-oriented way, to better understand the local resources management problem at hand as well as the ecological and socio-economic consequences of management action, other approaches rather focus on the development of specific management action. Uncertainties in water resources management are high. This is often based on the lack of adequate ecological as well as socio-economic data on catchment scale especially in the developing world, as well as on very limited knowledge on the behaviour of complex socio-ecological systems in principal. Approaching water management challenges in the developing world thus requires merging process-oriented research models that focus on knowledge generation with management concepts that focus on aspects of practical implementation. To further develop and implement sustainable approaches for water resources management that integrate knowledge generation and structured research into a management perspective, the establishment of flexible management mechanisms is required that allow changing the course of action if new knowledge is gained.

Three leading approaches have emerged in parallel in different scientific and political spheres in the field of water and natural resources management and research: Integrated Water Resources Management, Adaptive Management and the Ecosystem Approach. Each concept is based on different, rather complementary than contradictive, principles and tools. The following chapters reflect these approaches in the context of the boundary work framework.

2.4.1 Integrated Water Resources Management (IWRM)

During the last decades, the concept of Integrated Water Resources Management has emerged as the leading approach towards sustainable water resources management for both, the developed and the developing world. While in the past, water resources management was characterized by defined operational problems, which where individually addressed and solved through techno-centric solutions, such as water quality improvement through water treatment, flood control through dam construction etc., the concept did not embrace the complexity of eco-systems, here the water systems and related natural resources. In acknowledgement of this complexity, further holistic approaches of IWRM have been developed and brought forward through several international organisations, such as Global Water Partnership (GWP), International Water Management Institute (IWMI), Food and Agricultural Organisation (FAO) et al.

IWRM is meanwhile the accepted 'leitmotif' for sustainable water resources management. However, it still lacks success in practical implementation for several reasons. The natural resources management model provides an ample range of principles and tools to develop localised solutions, but lacks a structured methodology on how to proceed to address a concrete problem. It does furthermore not systematically incorporate the necessity of structured knowledge generation and the integration of research activities into the development of management solutions. And it does not acknowledge in enough detail the required integration of local governance perspectives (see also Chapter 2.5). As leitmotif, IWRM has the potential to serve as a boundary concept for water resources management (WRM). However, it has been interpreted in so many different ways that it would first require a harmonised understanding of what IWRM actually implies in order to function as a boundary concept for WRM. The multiple and diverse approaches of IWRM can be structured within three categories, reflecting different schools of thought (following Neubert et al. 2005):

The first set of definitions of IWRM covers intra- or mono-sectoral approaches, focusing on the water-sector only. This 'limited' view integrates groundwater and surface water in its quality and quantity, but does not consider other natural resources, like land and biosphere. It further excludes all water-related sectors, such as agriculture, industry or energy. An example for this perspective is given by the European Union's (EU) Water Framework Directive.

The second set of definitions is slightly more comprehensive and covers intersectoral approaches. In the foreground are allocation problems through competing forms of water use, which shall be solved through coordinated action between different sectors. An additional focus may be set on protection of the natural resources. Examples cover e.g. the integration of the agricultural perspective into water management[8], or analysis of ecosystem services and their interrelations with different forms of water use[9].

The third set reflects a holistic approach, as defined by GWP (2000: 22): *'IWRM is a process, which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.'* This holistic definition requires integration of different water-related spheres and aspects, i.e. merging a) natural and human system interaction, b) freshwater and coastal zone management, c) land and water management, d) 'green' and 'blue' water, e) surface water and groundwater management, f) quantity and quality in water resources management, and g) upstream and downstream water-related interests. Different interest groups shall jointly develop and manage the water resources in a participatory and catchments based approach, involving knowledge and actors from different sectors (water, agriculture, industry, energy et al.), different disciplines (natural science, social science) and experts as well as laypersons. This new catchments based approach acknowledges that from a natural ecosystem perspective, river basins − rather than administrative borders − are the logical planning units for water management. This holistic approach is further based on the four Dublin principles, which have commonly been agreed upon by the international community as guiding principles for water resources management (GWP 2000: 13−14):

'I) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

II) Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.

III) Women play a central part in the provision, management and safeguarding of water.

---

[8] see e.g. <www.iwmi.cgiar.org/>, viewed 29 May 2015.

[9] see e.g. <www.riverbasin.org>, <www.iucn.org>, both viewed 28 May 2015, and Dehnhardt and Petschow (2008).

IV) Water has an economic value in all its competing uses and should be recognized as an economic good.'

While the approaches of the first and second set of definitions imply a certain interest in specific outcomes (e.g. improved water quality, flood control or protection of the natural resources), the third category does not focus on one specific issue of concern, but leaves it to the actors to identify the prevailing problem by themselves. In this openness and universal perspective it is suitable as 'leitmotif' for water resources management, but so far it lacks a protocol for approaching concrete problems and it thus can prove only little success in practical implementation. In the following I will analyse and discuss the boundary work framework in the light of this third and holistic concept of IWRM:

Boundary concepts and IWRM: As outlined before, the principles of the holistic perspective of IWRM can be summarised as follows: IWRM claims to base management solutions on the integration of all concerned stakeholders and natural resources that are involved in the water cycle in a catchments-based approach. All stakeholders should have the possibility to get actively involved in the decision making process. This shall warrant a greater acceptance and legitimacy of management decisions. IWRM itself could serve as a boundary concept. However, as interpretations of what it implies strongly vary, it is not yet ready to function as boundary concept without further harmonisation of its principle meanings.

Boundary objects and IWRM: Trying to foster practical implementation of IWRM, GWP has developed a complex toolbox for knowledge sharing and capacity building[10]. The toolbox consists of fifty-nine tools for implementation of IWRM, more than two hundred case studies illustrating how the tools work in practice and an ample range of reference materials on critical challenges, cross-cutting issues and publications (support documents, annuals, papers, external IWRM databases). Apart from serving as dissemination platform for IWRM, it shall enable decision-makers to make informed and rational choices for sustainable water management. It does not aim for a 'one-size fits all' solu-

[10] <www.gwptoolbox.org>, viewed 28 May 2015.

tion or blueprint for IWRM, but for the development of individual solutions for concrete water management problems acknowledging the prevailing local conditions.

The tools are organised within three categories: a) the enabling environment (through policies, legislative framework and financing and incentive structures), b) institutional roles (creation of appropriate organisational frameworks and institutional capacity building) and c) management instruments[11] Starting from the individual problem − e.g. allocation problems and user conflicts, water scarcity or water quality deterioration − decision makers can chose a suitable mix and sequence of tools addressing their specific problem. Though providing a comprehensive overview on topics that may be considered when analysing and approaching water problems, it requires high-level water experts and resources to be able to process and implement these tools. The 'toolbox' can rather be considered as knowledge base for information sharing among high-level water experts than for enabling decision makers to work with it in a practical manner without external consulting.

However, in the context of boundary work for the water sector, the toolbox provides a comprehensive overview of areas of concern in water resources management and many secondary sources and supporting documents to learn how to approach specific issues. The overview about areas of concern can be used to support problem identification and problem structuring. The secondary literature – varying in its quality and quantity on specific topics – may then support the structured development and implementation of processes and products to approach the problem.

Boundary settings and IWRM: Two critical aspects of the holistic IWRM perspective shall further be enlightened when reflecting upon boundary settings: the principle idea of a fully participatory approach towards planning and management and the role of the political regime in IWRM. One of the most chal-

[11] Management instruments are categorised as follows: water resources assessment, IWRM planning, demand management, social change instruments, conflict resolution, regulatory instruments, economic instruments and knowledge and information management

lenging ideas reflected through IWRM is that an inherently transdisciplinary planning and management approach should in all stages be implemented in a participatory manner, giving all concerned stakeholders the right and possibility to get actively involved in planning and management to jointly develop sustainable solutions in areas of conflicting interests. This idealistic and ideological approach on 'how IWRM should be' − following a Habermasian logic − has often been criticised as not applicable in real-life cases. (Saravanan et al. 2008). IWRM can be regarded as 'society centred framework or policy process', assuming the presence of societal groups, which are contesting current water policies and management approaches and are actively and critically involved in sector-specific policy debates. Whereas Grindle (1999) shows that often developing countries may rather be characterised by 'state centred' policy processes which are characterised by low level or absence of active public engagement, as for instance in (semi-) authoritarian regimes. IWRM is furthermore based on assumptions on an 'ideal speech situation', in which all affected stakeholders have the room and right to participate in the discourse, without being inhibited by prevailing power distribution (Saravanan et al. 2008, Alexander 2001: 313). This as well is not given in state-centric or (semi-) authoritarian regimes.

Whether or not the strictly participatory IWRM approach is instrumental for achieving sustainable water resources management in developing countries strongly depends on the prevailing local political system and culture. Critics of the idealistic IWRM-approach − following a Focouldian logic − emphasise that integration of all stakeholders is diverse and is a political process (Hofwegen and Jaspers 1999, Allan 2006, Saravanan et al. 2008). To aim for real-life solutions, this idealistic approach should be combined with 'strategic action' approaches, acknowledging the political dimension of water resources management in the diversity of actors, power-relations and interests. A realistic and contextual analysis of prevailing power dynamics seems to be a pre-condition for appropriate adaptation and application of the concept. Overarching regime aspects and power relations need to be considered when analysing the 'external boundary settings', or else, the framework conditions in which the project and the problem are set. This helps to reveal limitations to change.

In addition to the required consideration of regime aspects, in developing countries deficiencies in what is called ‘the enabling environment’ are rather typical and the water sector is often characterised by fragmentation, inadequate institutional and administrative structures with unclear roles and responsibilities, inadequate regulatory mechanisms, lack of data and information and lack of resources in terms of qualified staff and money. Competing organisations (ministries, departments, state-, regional and local governments) claim legitimacy for their existence and may not be interested in knowledge sharing and joint management of water resources. This as well may be covered under the concept of ‘external boundary settings’. Working on an ‘enabling environment’, or trying to influence these boundary settings through adapting laws, policies and financing mechanisms provide the framework for successful IWRM. However, these are slow processes that may take many years to decades – generally longer time frames than a projects’ lifespan. Depending on the task, scale, objective and duration of a project, they need to be considered as given or ‘unchangeable’ conditions that confine change. It further needs to be reflected to what extent − if at all − externally financed projects are legitimated to get involved into working on changing these framework conditions in the local context.

Developing the boundary work perspective for water resources management in the developing world needs to face up to the bias among participatory reform approaches and state-centred realism. The analysis of external boundary settings as described above helps to reveal limitations and limits to change and to design the process of project implementation in a contextualised manner – thus with a higher or lower level of participation, according to the local culture.

2.4.2 Adaptive Management (AM)

To address deficiencies of IWRM, current research is focusing on merging relevant aspects of Adaptive Management into IWRM approaches for concept improvement (Medema and Jeffrey 2005, Medema et al. 2008, Pahl-Wostl et al. 2007). The origins of the Adaptive Management approach are under dispute: according to some authors the concept of Adaptive Management has its sources in systems and complexity theory, was launched in the 1970's and was originally meant to improve understanding of complex ecosystems and functioning. Following other authors, the origin may be claimed in the decision analysis field, aiming at supporting structured decision making in complex decision situations in natural resources management (Walters 1986).

The AM approach focuses on two conceptual weaknesses of IWRM: a) it acknowledges uncertainty in understanding human-ecosystem behaviour, the effects of management action and impacts of large scale environmental changes, e.g. through climate change, and b) the inherent capacity of natural systems to self-adapt to changes in their environment (Medema and Jeffrey 2005, Pahl-Wostl and Sendzimir 2005). Human-ecosystems − here water resources systems − are characterised by a high level of complexity and change, which makes it difficult, if not impossible, to fully understand the system and its interrelations. Complexity in human-ecosystems or socio-ecological systems refers a) to the array and variety of components (ecological, physical, technical and human) forming the ecosystems as well as b) to the multiple and diverse relations (ecological, economic, social, political and physical) interlinking these components. The system is constantly in revision and modification, reacting on changes or anticipating future changes and contains many niches, which can be filled by agents adapting to them. Due to this complexity and mostly non-linear behaviour of ecosystems, performance and developments are mostly unpredictable.

The very limited human knowledge on functioning of complex ecosystems leads to management-decisions which are based on high levels of uncertainty and which hardly allow to overlook and understand the consequences of the decisions in the long-term. There are different types of uncertainty which need to be acknowledged in water resources management, e.g. lack of knowledge based on limited data availability in quantity and quality, limited understanding of current systems' behaviour (agents and their interactions) as well as uncertainty in anticipating the ecosystem's reaction on management action and unpredictability of large-scale environmental changes, e.g. through climate change and their consequences for the local social-ecological systems. Furthermore the diversity of stakeholders can create uncertainties, based on different even contradicting interpretations of the same data and information due to different perceptions and values of the stakeholders.

Considering uncertainties in water resources management requires the development of flexible management systems and innovative and robust management strategies. These need to incorporate knowledge generation into the management approach and allow changing the course of action if new knowledge is gained. Management systems need to be flexible to react on new knowledge, as new information may require a total shift in the management approach and can even contradict previous management action. New knowledge can cover environmental, socio-economic or technological fields, e.g. through better understanding of the systems behaviour in general; improved knowledge on (large scale) environmental changes such as climate change or an increased awareness of socio-economic and demographic changes. A central element in AM is the perception that complex management systems should not aim at reaching a state of equilibrium, but rather be able to integrate past management experiences and increasing knowledge in the current management approach.

Acknowledging complexity and uncertainty leads to four major principles for AM (Ohlson 1999: 14–15): It requires continuous and deliberate learning; it supports knowledge generation through field science and formal experimentation; it is based on a systems approach and it integrates management and research (for further information see Annex 1). In this aspect AM is an evolvement to IWRM. Acknowledging uncertainties, it goes beyond a pure management approach and requires to base management decision on structured learning processes and research. The principle of integrating management and research into a single concept can add to the IWRM perspective, which so far does not include structured approaches for knowledge generation.

While from a conceptual perspective AM provides important principles, tools, planning frameworks and experiences, its practical applicability still needs further experiences and research. Success in implementation of this participatory 'soft systems approach' is so far limited and depends on scale and issue under dispute. Some tools for water resources management, such as DSS, can be highly resource intensive and sophisticated, and practical use may be limited (see also Chapter 2.3), however, some generic processes and less sophisticated tools may add to developing suitable boundary objects and support the structured reflection of boundary settings that hamper or limit potential change. Examples for AM approaches mostly refer to small-scale application and modelling rather than experimentation. Success in implementation also depends on the specific local political and cultural conditions: AM requires flexible political and social systems, open to deal with a qualitative and inclusive process rather than focussing on quantitative results. As discussed in the context of IWRM, this may cause difficulties in state-centric or (semi-) authoritarian political regimes as often encountered in the developing world (Mollinga 2009, Padt 2009).

Further challenges occur during the implementation phase of AM. To cite just a few of the noted problems, the range covers: '*failure to define what is meant by AM and how it will be implemented; an absence of strategic thinking of the end-points of scientific inquiry; tendency for AM processes to evolve into continuous and costly modelling exercises; fear on the part of individuals in management agencies that acknowledging uncertainty will compromise public confidence in the agency; failure of the scientists to understand management priorities and to recognize the need to provide information that can directly be used by managers in decision making; lack of emphasis or attention to the processes required for shared understanding or shared decision making among diverse stakeholders*' (Ohlson 1999: 19, following Halbert 1993, McLain and Lee 1996, Rogers 1998, Walters 1997). In principal, AM adds to the comprehensive reflections on boundary work in water resources management and research by providing important extensions, while IWRM still remains the general 'leitmotiv' for WRM. In the following, AM shall be analysed and discussed through the perspective of the boundary work framework:

Boundary concepts and AM: The Adaptive Management approach adds important principles to the IWRM perspective: it acknowledges that human-ecosystems are complex systems that are characterized by uncertainty. AM thus acknowledges the need to structurally merge management with research models to enable decision makers to take decisions based on scientific policy advise. Sound management of complex systems requires structured learning and research, which is facilitated through field science as well as experimentation. The principle of integrating management and research into a single approach can add to the IWRM perspective, which so far does not yet include structured approaches for knowledge generation.

Boundary objects and AM: AM is an approach, in which in a structured learning process knowledge improvements in environmental, socio-economic or technological fields and learning from previous management actions is taken to improve the next stage of management (Holling 1978, Walters 1986). This is based on a participatory and inclusive management approach. Ideally, committing to a joint process of structured learning, reflection and adjustment may even support mediation and cooperation between conflicting stakeholders.

AM can be split into the two streams of passive AM and active AM (see e.g. Medema et al. 2008, Walters and Hilborn 1978). Both paths, active and passive AM, reflect 'boundary objects', be it in terms of (participatory) processes that aim for social and institutional learning or through the development and application of products and tools, like models and experiments, that help to communicate problems, bridge perceptions and support common decision making between various actors. Passive AM *'formulates predictive models of ecosystem responses to management actions, bases management decisions on model predictions, and uses monitoring data to revise model parameters'* (Medema et al. 2008 following Walters and Hilborn 1978). In Passive AM, historical data is usually used to model trends and propose one single course of action. Outcomes are monitored and evaluated and the course of action is adjusted, if new information is available. It can be considered as 'trial and error' learning, which cannot be afforded in water resources management, as the potential 'error' implies serious and irreversible threats for human well-being and the respective ecosystem.

While passive AM sets more on modelling, active AM better reflects the contextualisation of problems through real-life experiments. Alternative management options e.g. the implementation of new policies, are proposed and tested in small- to large scale experiments. Monitoring and evaluation of the consequences may allow an interpretation, whether or not the specific policies or approach in the pilot projects are suitable to achieve the desired outcome or if adjustments are needed. It then bases new management decisions and action on the outcomes of these experiments. However, while active AM provides more information on possible outcomes of alternative management decisions, it is − depending on the scale to be addressed − resource intensive in terms of costs and staff involvement. It further requires close cooperation between different actors, willing to jointly learn and act on new knowledge. The approach can be reflected in a structured learning cycle (Figure 1):

Figure 1 The structured learning cycle (Medema and Jeffrey2005: 25, taken from National Oceanic and Atmospheric Administration Coastal Services Center)

As a matter of principle, the first proponents of AM did not want to provide operational guidance how to implement AM, as this was assumed to diminish the intended flexibility. However, in the course of time a generic approach for AM has emerged. The Generic Adaptive Management Process, as described by Ohlson (1999: 13−14), can be summarised as follows (for a quotation in full length see Annex 2):

1. ‘*Define problem boundaries*
2. *Identify key uncertainties*
3. *Choose ecosystem indicators*
4. *Generate alternate hypothesis*
5. *Design management experiments*
6. *Implement and monitor*
7. *Feedback results*’

Translating this into more specific action includes the following steps to be continually repeated:

1. ‘*Establish a stakeholder adaptive management team*
2. *Define the problem(s) to be addressed*
3. *Establish goals and objectives*
4. *Specify a conceptual model that expresses the collective understanding of how the system in question functions, highlighting key uncertainties and acknowledging factors that are outside of the system*
5. *Develop hypotheses about the effects of different management actions that address the uncertainties*
6. *Design management experiments/interventions to test hypotheses while meeting management goals*
7. *Design a monitoring plan to measure the impact(s) of management interventions*
8. *Implement management interventions*
9. *Monitor*
10. *Evaluate the impacts in terms of management goals and hypotheses*
11. *Reassess and adjust the problem statement, goals, conceptual model, interventions, and monitoring plan.*’

(Medema and Jeffrey 2005: 25, following Johnson 1999, Levine 2004, Parma et al. 1998, Walters 1997). ‘*As a result of this cyclical learning process, the focus is on response and scenario building based on the monitoring of carefully defined indicators of system state and behaviour rather than on long-term prediction from first principles or past statistics and information.*’ (Medema and Jeffrey 2005: 25 following Clark and Gardiner 1994).

For implementation of the processes various tools are available, covering small- to large scale field experimentation, ecosystem modelling and transdisciplinary stakeholder workshops to analyse and reflect upon prevailing problems and outcomes of management experiments, to redefine targets and to jointly adapt the course of action (for details on tools in AM see Annex 3). The generic processes as described above are boundary objects themselves, such as the concrete tools as presented in Annex 3. In a next step, the processes serve as input for the development of a methodology how to approach complex natural resources management problems and develop the instrumental work for action, as proposed in Chapter 2.7.

Boundary settings and AM: Reflections and studies that have been conducted in the field of AM may be of further support for the structured analysis of conducive or hindering boundary settings. Raadgever et al. (2008) have developed a framework for assessing the adaptive capacity of regimes in transboundary river basin management. While the focus is on the international and transboundary level, all elements also apply to national or local scale. Raadgever et al. have identified five key features of (adaptive) transboundary management regimes: actor networks, water law, water policy, information management and financing systems. For each element, the authors provide further explanations, examples, criteria and indicators for assessment of the local framework conditions. An overview on relations is given in Figure 2:

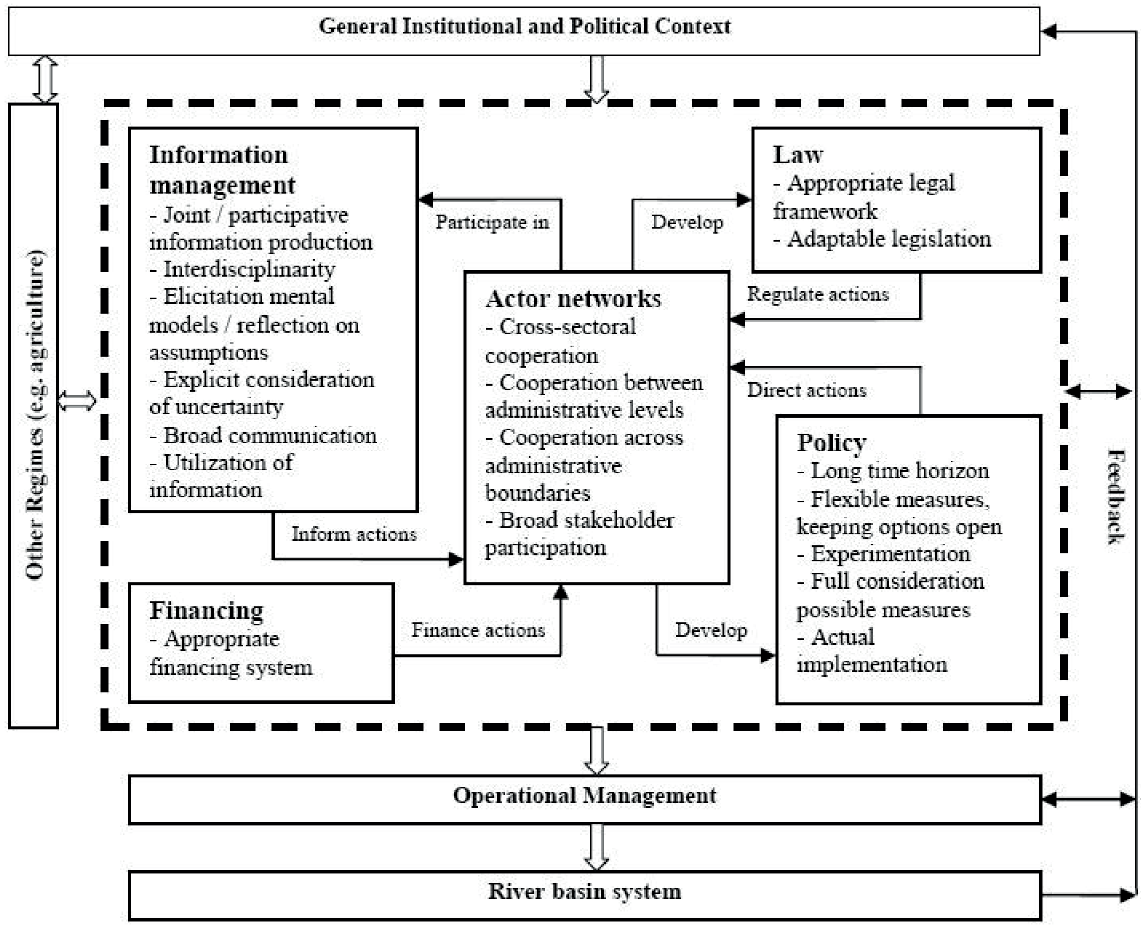


Figure 2 River basin management regime and criteria for adaptive management (Raadgever et al. 2008: 4)

Without going into further detail now, the framework may serve for reflections on boundary settings for tangible local water issues and a contextual analysis of supporting or hindering factors for the project. A comprehensive overview about the framework is given in Annex 4.

2.4.3 The Ecosystem Approach (EA)

The Ecosystem Approach is considered as one of the leading concepts for sustainable management of natural resources and reflects a paradigm shift from protected area management to a holistic management perspective, acknowledging that ecosystems, apart from their intrinsic value, provide goods and services to the people. The approach has been developed under the Convention on Biological Diversity (CBD) (United Nations 1992) and is meant to provide operational guidance on implementation and balancing its three core objectives, namely '*the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.*' (United Nations, 1992: Article 1) and is defined as '*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.*' (CBD Dec. V/6 Annex A, section 1[12] or Secretariat of the Convention on Biological Diversity (2004: 6)). It shall provide operational guidance to balance the three objectives, acknowledge the complex interconnections between ecological, social, cultural, economic and institutional factors and take into account that humans with their cultural diversity are integral parts of many ecosystems.

It further intends to approach environmental degradation including climate change mitigation and adaptation with the aim to increase human well-being and contribute to poverty alleviation. For its application to a concrete project or issue, it provides a framework in terms of twelve principles, operational guidance in five steps and an ample range of specific tools[13]. Through its holis-

---

[12] <www.cbd.int/decision/cop/default.shtml?id=7148>, viewed 28 May 2015.

[13] An introduction to the Ecosystem Approach is given at: <www.cbd.int/ecosystem>, an overview on how to apply the EA is provided through the 'beginner guide' on: <www.cbd.int/ecosystem/sourcebook/beginner-guide/>. For more details on the appli-

tic approach and operational guidance it may add to the IWRM perspective. However, on a conceptual basis only first attempts have been made to merge EA with IWRM or to convey ideas of one concept into the other (Dehnhardt and Petschow 2007). EA may further provide approaches for the development of boundary objects and the analysis of boundary settings in complex water resources management issues.[14]

EA defines twelve principles that form the conceptual basis of the approach (see Annex 5) that all may also apply for IWRM. The ecosystem approach does not specify a spatial unit or scale to be addressed, but focuses on functional ecological units at any scale. IWRM requires water resources management to be oriented at catchment boundaries, which would here define the spatial unit to be addressed. It is further based on the understanding that apart from their intrinsic value, ecosystems provide goods and services to the people; these can be divided into goods, or else 'provisioning services' such as water, fibre and food, regulating services, e.g. emissions sinks or flood control, cultural services, e.g. recreational, spiritual, religious benefits and supporting services, e.g. soil formation and nutrient cycling. There exist substantial linkages between the sustainable provision of ecosystem services and human well-being: '*Human well-being and progress toward sustainable development are vitally dependent upon improving the management of Earth's ecosystems to ensure their conservation and sustainable use*' (Millennium Ecosystem Assessment 2003: Summary: 1)[15]. The linkages revealed between ecosystem services and human well-being are briefly presented below (Figure 3):

---

cation of the EA see the 'advanced user guide': <www.cbd.int/ecosystem/sourcebook/advanced-guide/> and for information on specific tools and approaches, see <www.cbd.int/ecosystem/sourcebook/tools/>, all viewed 28 May 2015.

[14] For the EA and its applicability to water resources management see also Dehnhardt and Petschow (2007).

[15] According to the Millennium Ecosystem Assessment (2005), human well-being has various constituents, covering: basic material for good life (adequate livelihoods, sufficient nutritious food, shelter, access to goods; security (personal safety, secure resource access, security from disasters); health and physical well-being (strength, feeling well, access to clean air and water), good social relations (social cohesion, mutual respect and ability to help others) and freedom of choice and action (opportunity to be able to

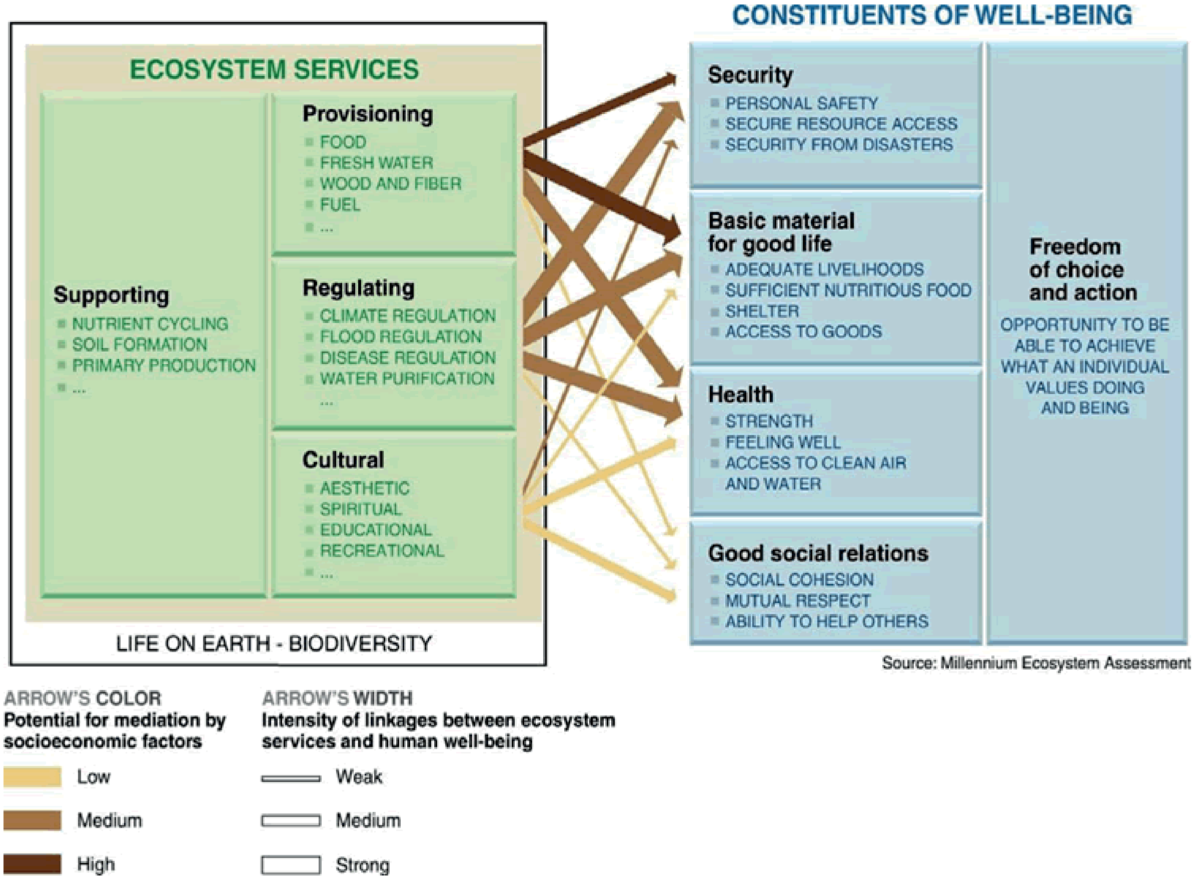


Figure 3 Linkages between ecosystem services and human well-being (Millennium Ecosystem Assessment 2005: vi)

Human well-being has been considered as central focus for the assessment. This will be taken as overarching principle and objective when reflecting on boundary work for sustainable water resources management. In the following, the EA shall be reflected in the view of the boundary work framework:

Boundary concepts and the ecosystem approach: The Ecosystem Approach reflects a paradigm shift in natural resources management from protected area management to a holistic management perspective, acknowledging that ecosystems apart from their intrinsic value provide goods and services to the people. It is a general strategy that supports balancing the needs for human development with ecosystem health, based upon principles of fairness and equity. It aims for both: protection of natural resources as well as their sus-

achieve what an individual values doing and being). Well-being is strongly context specific and dependant on geography, culture and ecological framework conditions.

tainable use in an adaptive and flexible way. EA provides twelve principles that outline the theoretical basis of the approach (see Annex 5). They all may apply also for integrated water resources management. For applying the twelve principles, further 'steps' are proposed as operational guidance (Annex 6), however, they rather reflect additional principles themselves. Human well-being is reflected as overarching principle and objective. This shall be acknowledged in the boundary work framework, when developing it for the context of sustainable water resources management in the course of this research.

Boundary objects and the ecosystem approach: The EA provides not only operational guidance and tools for its application, but also further experience through the process of the Millennium Ecosystem Assessment (MA). When applying the EA, five steps are proposed, which themselves constitute a boundary object in terms of a process, but also provide input for the reflection of a generic methodology to develop instrumental work for action in natural resources management problems. The steps cover (Secretariat of the Convention on Biological Diversity n.d.):

1. Problem definition;
2. Identification of the tasks required to address the identified problems (the twelve tasks to be reflected are presented in detail in Annex 7);
3. Recognition of crosscutting issues, such as capacity building and participation; information, research and development; monitoring and review as well as governance;
4. Creation of a management plan;
5. Implementation of the management plan or the project.

The focus is on management and implementation, less on research to adequately address knowledge needs in a transdisciplinary approach. Here approaches from Transdisciplinary Research may considerably add to the Ecosystem Approach and its potential use for boundary work in water resource management.

Additional conceptual work that may support the development of boundary objects and decision-making in complex WRM problems is reflected in the Assessment Framework for the MA (Millennium Ecosystem Assessment 2003).

The framework shall serve decision makers as mechanism to '*identify options that can better achieve core human development and sustainability goals; better understand the trade-offs involved – across sectors and stakeholders in decisions concerning the environment and align response options with the level of governance where they can be most effective.*' (Millennium Ecosystem Assessment 2003: 2–3) The analytical steps to be conducted cover the following (Figure 4):

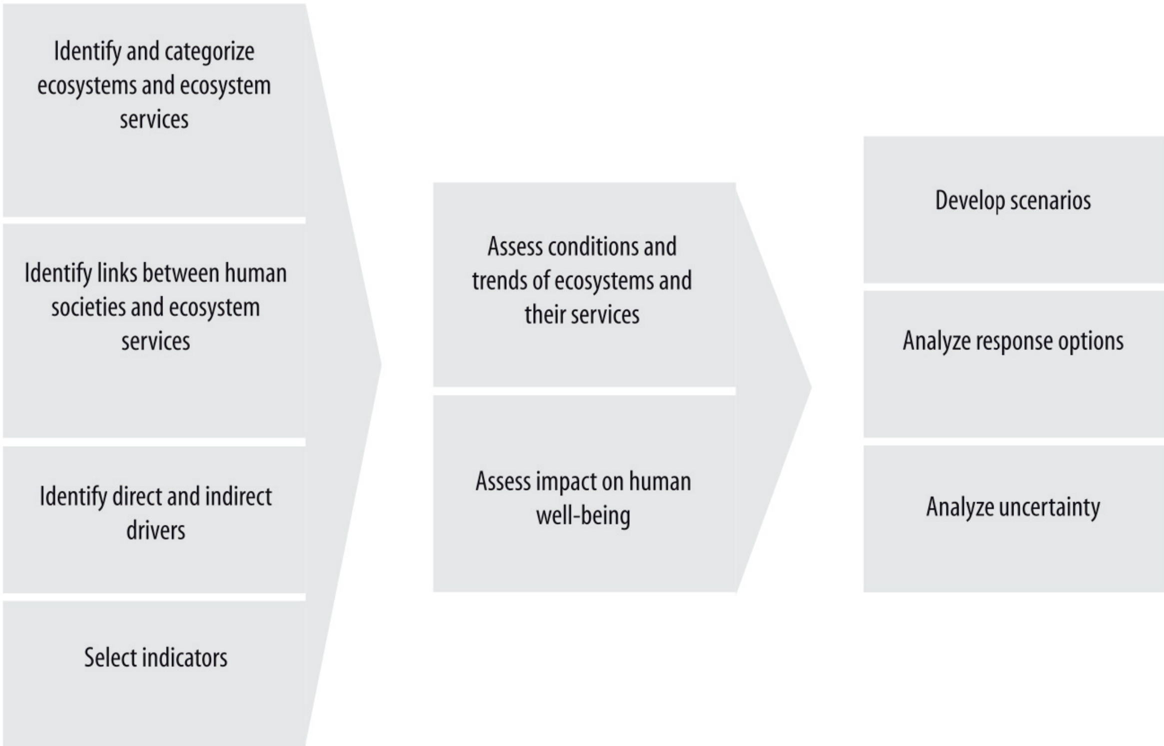


Figure 4 The analytical approach of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2003: 149)

For details on the nine tasks see Annex 8. However, scenario development, analysis of response options and analysis of uncertainty are then approached through extensive modelling exercises in the fields of environmental system modelling and human system modelling. If and to what extent modelling is an appropriate and required boundary object in water resources management strongly depends on the local problem to be addressed and the available resources in terms of staff, time and money and needs to be assessed in the specific local context.

Boundary settings in the ecosystem approach: Some reflections in the context of this framework for assessment may proof to be suitable for the analysis of Boundary Settings. The MA applies a multi-scale approach, whereas 'scale' describes the physical dimension of a process or an issue, in space or time. '*A multiscale approach that simultaneously uses larger- and smaller-scale assessments can help to identify important dynamics of the system that might otherwise be overlooked. Trends that occur at much larger scales, although expressed locally, may go unnoticed in purely local-scale assessments*.' (Millennium Ecosystem Assessment 2003: 107). Reflections on space and time scales of ecological and social processes can help to reveal limits for change during a projects’ life span. While some processes like small-group decisions can be implemented in relatively short periods of time (according to Figure 5 in periods between months and one year), the change of 'the enabling environment' in terms of policies, laws or even culture and traditions may span decades to a millenniums. It is thus worthwhile to analyse cultural, political, legal and institutional framework conditions in complex water resources management issues in the context of their spatial and temporal dimension to reveal potential changes during a projects life span. If they lay within spatial or timeframes that are beyond the projects conditions, they need to be acknowledged and reflected as limiting factors for change.

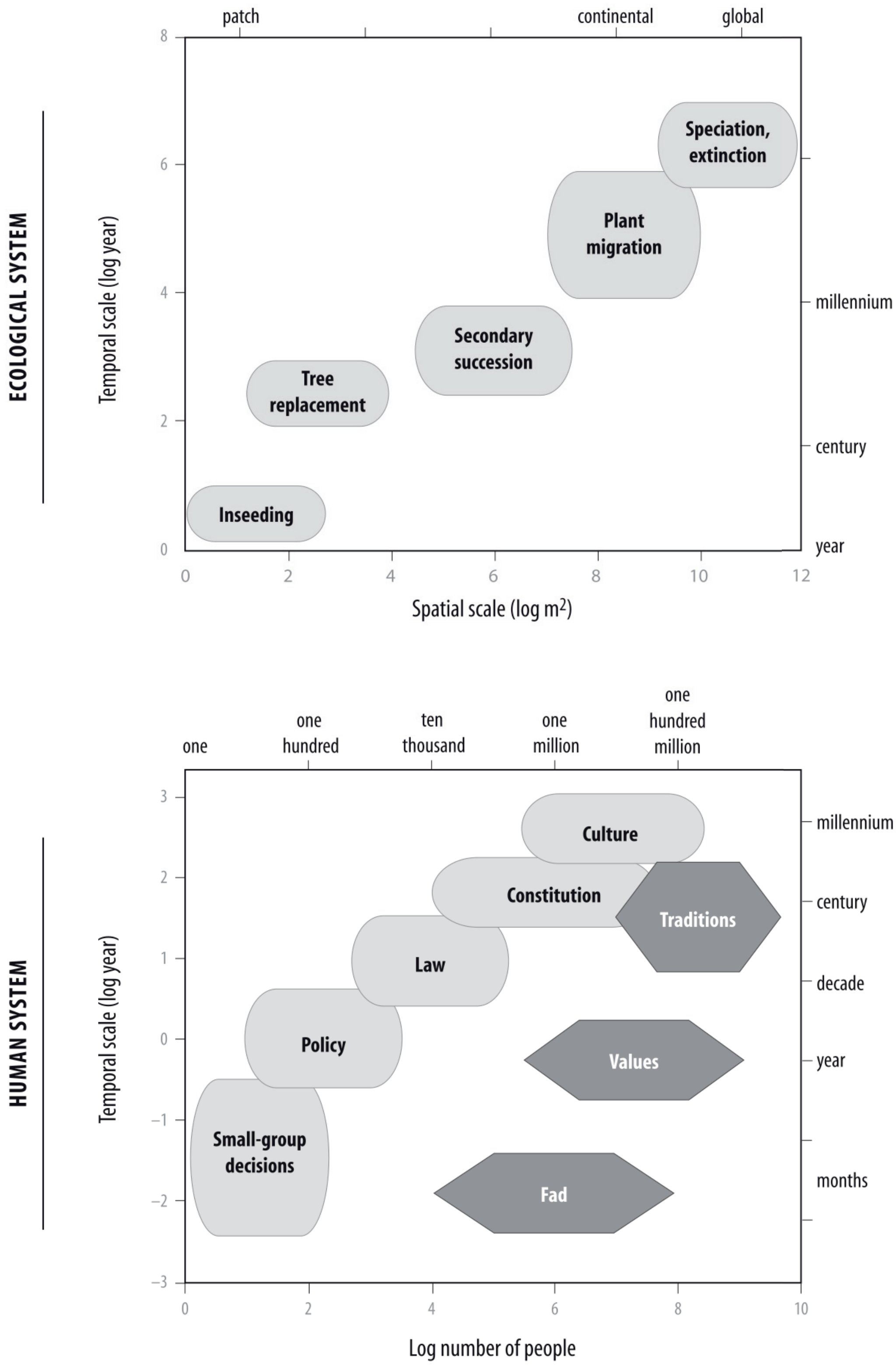


Figure 5 Time and space scales for selected ecological and social processes (Millennium Ecosystem Assessment 2003: 116)

2.5 Water Governance

Water in sufficient quality and quantity provides a fundamental basis for human and ecosystem well-being as well as human development. Water resources management is an inherently political process that affects civil society by dealing with questions of allocation, regulation, administration, policy, politics et al. This requires including questions of (good) water governance into the perspective of water resources management. While the discussion of the concept of IWRM already reflected a paradigm shift from technocentric approaches of 'infrastructure development and operation' to a holistic management approach, failures in implementing IWRM can be assigned to the fact that governance aspects had not been incorporated in enough detail: *'There is an emerging consensus that this failure (of implementing IWRM) could be due to inadequate attention being paid to ensuring that appropriate governance systems are in place; and this appears to be due to very varied understandings as to what constitutes good governance.'* (Turton et al. 2007: 3, following WWC 2000).

Governance is inherently different from government; definitions of governance may but do not have to relate to government. Governance is a complex process that incorporates all kinds of relationships within and beyond the state; besides governmental institutions it covers also relationships between science, civil society, the private sector, formal and informal organisations et al. In general, it '*describes the relationships between people, the ways they interact with each other in the context of their environment, and the systems of principles, rules and norms that are set up to guide these interactions'* (Turton et al. 2007: 7). 'Good governance' further implies that relationships and processes are transparent and all parties are accountable for their behaviour. A more comprehensive definition thus would be: Governance is '*the process of informed decision-making that enables trade-offs between competing users of a given resource so as to balance protection with beneficial use in such a way as to mitigate conflict, enhance equity, ensure sustainability and hold officials accountable.'* (Turton et al. 2007: 12).

If governance focuses on water as central element of concern, it is considered as 'water governance'. GWP defined water governance as '*the range of politi-*

cal, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels in society' (Turton et al. (2007) following Rogers and Hall 2003: 7). However, a commonly accepted definition of 'water governance' still has to be developed. The prevailing way of local governance strongly depends on norms and values of the society in which it is applied. Thus experience in water governance from democratic countries, as mostly found in the 'developed world', may not be transferred to 'developing countries', which rather imply (semi)-authoritarian regimes to what can be considered 'fledgling democracies'. When dealing with water governance issues in the context of water resources management, the prevailing norms and values of different stakeholders and the norms and values founding the legal system need to be revealed and considered in the local context (following Turton et al. 2007: 7−14).

An interesting concept for reflecting upon water governance has been developed by Turton et al. (2007); it is considered as *'The Trialogue Model of Governance' (*Turton et al. 2007: 12−24). It will be presented here in greater detail, as it contains elements, which considerably add to developing the boundary work perspective to water resources management and research in the developing world. The model bases (water) governance on interactions between three main clusters of actors – the cluster of government actors, society actors and science actors:

Following Turton et al. (2007: 12−24), the governance cluster − reflecting the 'trias politicas' of political science − consists of three elements: the legislative branch of the government, engaged in rule making; the executive branch of the government, applying these rules; and the judicial branch, adjudicating on these rules. Policy and politics are in an ideal situation based on the needs of society.

The cluster of society actors embraces three sub-elements: civil society, including all individuals or groups of people that have an interest in engaging in areas of concern, such as non-governmental organisations, community based organisations, private entities, industry et al.; the second sub-element is the economy, with own interests and formal and informal channels of communication; the third element refers to the environment that encompasses society and economy.

The cluster of science actors focuses on knowledge generation. It is classified according to three subcomponents: 'basic research' (also considered as Mode 1 or Type A research) that focuses on analysing and understanding problems without the objective to develop solutions to solve them. Knowledge generation is strictly organised along academic disciplines; 'applied research' (also considered as Mode 2 or Type B research) focuses on solving real-life problems in a transdisciplinary manner; knowledge generation is contextualised and oriented at solving complex problems of societal concern (see also Chapter 2.7); apart from scientists with different academic backgrounds, also laypersons are involved in knowledge generation; Type C research refers to specialist services and technology transfer; services imply feasibility studies, consultancy reports, pilot projects etc. knowledge may be generated through a variety of actors from academia, private companies or civil society groups. Complementing this perspective, a fourth type of research can be added: '*use inspired basic research*' (Clark 2007: 1737). This is a curiosity driven type of research involving various disciplines and that draws upon basic as well as applied research. The field of 'Sustainability Science' fits into this category. Also research on Boundary Work is an example of this fourth type.

These actor-clusters are all somehow related to each other, which can best be reflected in the form of a triangle (Figure 6).

Figure 6 The three main actor clusters (Turton et al. 2007: 18, revised from Hattingh et al. 2005)

Communication and relation between the three actor-clusters is referred to as trialogue. Successful governance depends on effective communication and cooperation within and between the three groups of actors from government, society and science. Cooperation occurs along interfaces between government and science, government and society and science and society (Figure 7).

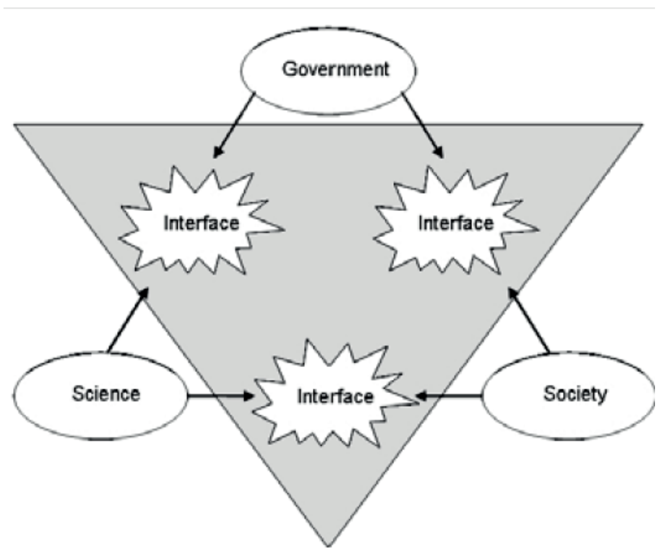


Figure 7 Governance as trialogue (Turton et al. 2007: 18)

The concept provides important insights that support developing the boundary work perspective according to the needs of water management in developing countries. It supports the structured reflection of boundaries in water resources management according to the three links of cooperation. It further gives insights into ‘boundary settings’, thus, the framework conditions that shape a project and define limits and limitations to change. Here the concept provides also a basis for reflections upon different types of governance regimes and the respective implications for cooperation between government, science and society (see Chapter 2.6). As water resources management problems are complex problems that require knowledge generation based on a functioning cooperation between these three actor-clusters, the prevailing governance type is crucial when reflecting upon limits for change in a local setting.

2.6 Developing the Boundary Work Framework for Water Resources Management and Research

The boundary work framework proposes a generic analytical cluster to assess and structure boundary work processes. Based on concepts, objects and settings, as reflected in the light of leading approaches for natural resources management (IWRM, AM and EA) (see Chapter 2.4), as well as the requirement to merge aspects of water governance, the following chapter contains analytical reflections and conceptual proposals on how to further develop the framework according to the needs of water resources management and research in the developing world.

So far boundary work literature either focuses on the analysis and approach of policy-science interfaces or in general on the demarcation between ‘science and non-science’. It did not yet systematically incorporate aspects of government-society relationships to reveal political framework conditions that considerably influence the success of a development- or research project. As water is a highly politicised resource, the development of sustainable solutions also needs to consider barriers and interfaces between government and society. According to the reflections in Chapter 2.5 on water governance and Chapter 2.2 on boundaries in water resources management, it is thus proposed to develop the framework by discussing barriers and interfaces according to the actor-clusters of government, science *and society*:

Barriers should be analysed on two levels: a) barriers within each actor-cluster and b) barriers between the three actor clusters. Barriers should further be classified according to their societal background: they can be institutional, cognitive, cultural or else.

Revealing **boundaries (and interfaces) between science and government** that set framework conditions for science **and between science and society** that support knowledge generation beyond academic limitations helps to analyse preconditions for successful transdisciplinary research. An appropriate process mode for knowledge generation in water management should systematically consider these linkages.

Analysing **barriers (and interfaces) between government and society** supports the understanding of political framework conditions that shape the project and help to appropriately contextualise it. They define ways, how good governance can be designed and they influence the possible modes of knowledge generation. Revealing these barriers further helps to understand and consider limits to participatory approaches, as they may not be in line with local governance practice and enforcement can hamper successful project implementation. Apart from following a dogmatic 'blind-alley' for participation at any means and without appropriate contextualisation, development and research organisations also need to reflect their legitimacy to involve into local governance practice. Analysing the government-society barriers provides a basis for these reflections.

Considering requirements for transdisciplinary research and conditions that support or hamper project implementation in the context of complex water management problems thus asks for a balanced reflection of boundaries between government, science and society. The boundary work processes that follow this analysis should then support a balanced trialogue between these actor-groups.

In the context of developing countries, this perspective further needs to incorporate a fourth actor cluster, constituted by international organisations that actively get involved in and shape water resources management. There exist different boundaries between the three (local) clusters of government, civil – society and science as well as the actor cluster of international organisations. This embraces a variety of different types of organisations, active at different scales and in different ways, such as governmental organisations, universities or other research organisations, private companies, non-governmental organisations or else. Boundaries exist between this cluster and local stakeholders, and also within the cluster, which can hamper effective international development cooperation. Barriers need to be analysed individually for each international organisation and in a project-specific way.

2.6.1 Boundary concepts and WRM

In the boundary work framework, ‘boundary concepts’ refer to the requirement of a common understanding as well as a commonly used terminology to solve problems in an inter- and transdisciplinary way. Reflecting the idea on ‘boundary concepts’ in the context of water resources management reveals two different types of required boundary concepts: a common understanding of **principles** that apply for sustainable water resources management as well as a common interpretation of the **terminology** used. Only if actors apply the same principles and associate the same meaning with the same words, communication and joint problem solving can be possible. The scope of boundary concepts for water resources management should thus be twofold:

Boundary concepts on principles: As described in detail in Chapter 2.4, there exist multiple attempts to define principles for sustainable water resources management. Though IWRM can be considered as leitmotiv for WRM, also this concept has many different notions. It can thus not be assumed that even the basic principles are commonly shared by the different stakeholders when discussing, what IWRM or ‘sustainable water resources management’ implies. Further, even the holistic understanding of IWRM as reflected through GWP has shortcomings in terms of relevant principles: this requires in the first place conceptual tuning on *principles.*

A proposal for boundary concepts in terms of principles for WRM is made in the following:

- According to the holistic understanding of IWRM, water resources planning and management should be based on an *integration of water, land and all related resources.* Their development and management shall *integrate all concerned actors and sectors* – be it experts or laypersons – and shall be based on *catchment boundaries* rather than administrative borders (see Chapter 2.4.1).
- AM adds the following principles: *Uncertainty* in understanding human-ecosystem behaviour needs to be considered when developing sound management solutions. Acknowledging uncertainty and knowledge gaps requires *merging management with research approaches* and modes of 'structured learning'. These combined approaches need to be flexible enough to allow changing the course of action, if new knowledge is gained in the research process (see Chapter 2.4.2).
- Sustainable management of natural resources implies balancing the needs for *human development* with *ecosystem health* − or the *use of natural resources* with the *protection of natural resources*, based upon principles of *fairness and equity* (see Chapter 2.4.3).
- Following the EA, the *overarching principle* for management of water and other natural resources is the aim for *human well-being*. (see Chapter 2.4.3)

Boundary concepts on terminology: When tackling a local issue, common interpretation of the core terminology needs to be assured. Which specific wording this implies depends on the prevailing problem; apart from 'water control' other examples for concepts are e.g. 'value' or 'fairness and equity' in the context of water pricing, 'risk and vulnerability' in the context of water supply, 'efficiency' in the context of water use, 'sufficiency' regarding water quantity etc.

2.6.2 Boundary objects and WRM

As described above, Mollinga's classification differentiates between three types of boundary objects. Depending on their route of development, this covers models as mediators (analytical route), frameworks, matrices, flowcharts (assessment route) or participatory approaches (participatory route). However, boundary objects in their general definition cover more than what is classified according to this framework. Boundary objects are all tools, devices and methods that *'sit between two different social worlds, such as science and non-science, and they can be used by individuals within each for specific purposes without losing their own identity'* (Guston 2001: 400, following Star and Griesemer 1989).

Reflecting the type of boundary objects that are comprised in the selected three core approaches for natural resources management as well as discussed in literature on boundary work, a new classification system for boundary objects is proposed here. Boundary objects can be categorized in terms of organisations, processes, tools and products:

Organisations: Much of the literature on boundary work and boundary objects actually focuses on entire *organisations* that serve as bridge, mostly between science and policy or government (see e.g. Agrawala et al. 2001, Cash 2001, Guston 2001, Huitema and Turnhout 2009, Keating 2001, Miller 2001, White et al. 2008). However, boundary organisations may also bridge between other social worlds, such as science and society or policy and society, which has so far not been systematically reflected in the context of boundary work. These organisations are then called 'boundary organisations'.

Most case studies retrospectively analyse how boundary organisations have evolved and what were supporting and hindering factors. Examples for boundary organisations are e.g. the Netherlands Environmental Assessment Agency, working on scientifically valid policy assessments and evaluations for policy and politics in environmental fields (Huitema and Turnhout 2009) or the United States' American Health Effects Institute that is meant to bridge between air quality debates and health effect debates. Its origin stems from conflicts between the automobile industry and the United States' Environmental Protection Agency on the technical feasibility of emission standards for automobiles as well as the scientific basis for the National Ambient Air Quality Standards (Keating 2001). While boundary organisations in these analyses mostly just link policy and science, it is of question, how the public or civil society could stronger be involved. This is required when reflecting an approach of a critical and **public** sociology of water resources management (see also Mollinga 2008c, 2008d). While some authors rather focus on the historical evolvement of boundary organisations, others focus on different types of boundaries, such as institutional, ideological or cultural boundaries and analyse how to reflect and approach them (see Paulsen and Hernes 2003). Here experience from the field of management science may also add to the boundary work perspective.

Apart from entire organisations, also *groups and individuals* can serve as boundary objects. There was no literature found analysing the role of groups or individuals in the context of boundary work, however, in practical experience many processes on bridging barriers between different actors are initiated by one or more individuals that are technically and culturally respected by the different sides.

Processes: Boundary objects can also refer to entire *processes* of project planning, development, management and / or implementation, be it in (fully) participatory manner or else. Processes can serve as mediators between the actors involved, reveal diverging interests, support mediation but may also increase barriers, if not all actors of concern are included. Here the original classification of boundary objects in Mollinga's framework fits: different processes (analytical, assessment, participatory) lead to different outputs or products – which themselves serve as boundary object. Adaptive Management or Transdisciplinary Research are boundary objects in terms of processes that support knowledge generation.

Especially with regard to participatory processes an ample range of literature exists on experiences, methods and tools. As described previously, the appropriateness of process solutions has to be considered in the light of the political regime and governance practice of the specific country.

Tools: Tools are devices that help to carry out a particular task. There exist an uncountable number of tools to approach water problems. Classification can be oriented along the structure of the GWP toolbox for IWRM (see Chapter 2.4.1) and be linked to the boundary work framework: tools to support the development of an enabling environment can be used to supporting the 'stretching' of external boundary settings; tools to create appropriate organisational frameworks can support the design of internal boundary settings or the structured development of boundary organisations; the tools proposed under 'management instruments' cover a broad range of aspects of assessment, planning and management of water resources.

Products: Institutions and / or individuals generate *products* to communicate about a problem or a situation. These products present knowledge and information in words, figures or graphics, e.g. through models, indicators, pictures, articles, reports, flow-charts, diagrams etc. They may reflect and picture the current state, ongoing developments, perceptions of different stakeholders, framework conditions, management options or possible outcomes of management actions. These products help all parties to better understand an issue; they support communication and facilitate the discussion.

Conjunction of organisations, processes, tools and products: None of the above categories implies stand-alone boundary objects. They always are, have been or will be related to one or more of the above categories of boundary objects in the process of approaching a complex problem, i.e. every boundary organisation has a history – a process that brought (conflicting) parties together and ended up in the decision of setting up this organisation, agreeing on funding schemes, lines of responsibility etc. Often these processes were initiated by individuals that started to bridge different social worlds. Communication was most probably facilitated through the development of products, in terms of presentations, reports, models etc. that served as basis for discussion and mediation. Products are developed through the application of tools.

2.6.3 Boundary settings and WRM

In the boundary work framework, 'boundary settings' are analysed in the context of research projects: internal boundary settings refer to the set-up between the involved research groups, external settings refer to the outer framework conditions of the project. Water resources management problems require combined research and management approaches, thus it is required to convey the idea of boundary settings not only to research but also to development projects.

While the shaping of internal boundary settings are of utmost importance for the effective implementation of development and research projects, the focus of this reflection lies on the analysis of external boundary settings in water resources management. Internal boundary settings can still be influenced during project implementation, while the analysis of external boundary settings helps to reflect limitations for change at the early stage of project design, as these are considered as unchangeable in the given time.

The necessity to think through political regime aspects when designing management and research projects has been discussed in detail in Chapter 2.5. In this context, the structuring of barriers according to the actor-clusters of government, society and science helps to identify, where limits and limitations to change may be encountered during the course of project implementation. Some reflections on the connection between regime aspects and their limitations for effectively bridging the barriers between government, science and society in a development context have been made by Linda Godfrey (2007): The 'strength of engagement' between the three actor clusters is presented in three models, differentiating between an 'undemocratic society' (model 1), a 'young democracy' (model 2) and a 'maturing democracy' (model 3).

In an 'undemocratic society' the interrelationships between government and society as well as between government and science are usually weak. Engagement with the government shows little success and governance is strongly ruled by the government only. In a 'young democracy', government and society strongly interact as the new government needs to assure transparency and accountability to maintain acceptance and legitimacy. However, it is noted that the connections between government and science as well as between science and society are not equally strong. The reasons for this can only be hypothesised and may vary between different countries. Depending on the role that science had played in the previous non-democratic regime, there may be no trust in the scientific community by society. To claim legitimacy, the government thus may not like to be associated with science. This is just one hypothesis of several that tries to give hints for the reason of the weak role of science in young democracies. However, in a 'maturing democracy' the interaction between government and society is getting weaker, while the acceptance of scientific actors by government and society is increasing. This is just a brief overview on the influence of regime aspects to the quality of engagement between different actor clusters.

It terms of practical guidance for the analysis of external boundary settings in water resources management I propose to orient along the 'framework for the assessment of the adaptiveness of management regimes in river basin management' as developed by Raadgever et al. (2008). The criteria provided require the analysis of actor networks, legal frameworks, policy, information management and financing mechanisms (for details see Chapter 2.4.2 and Annex 4). To illustrate limits to change, the results can also be brought into context with spatial and temporal scales of socio-ecological dynamics, as presented in Figure 5.

2.7 Making it Happen: Designing a Boundary Work Process

Having discussed the boundary work framework in the context of water resources management and research, a remaining question is: How can boundary work processes be designed from scratch, to support collaborative decision making in complex and contested water resources management problems in real-life cases? And further: How can 'instrumental work for action' − thus contextualised boundary objects − be developed for a specific case? Here, perspectives and insights from transdisciplinary research can analytically add to the science of boundary work. Preconditions or principles for TR are given by Pohl and Hirsch Hadorn (2007: 20). They state that '[*t*]*here is a need for TR when knowledge about a societally relevant problem field is uncertain, when the concrete nature of problems is disputed, and when there is a great deal at stake for those concerned by problems and involved in dealing with them.'* This holds true for almost all problems in water resources management (see also Mollinga 2010c). It can be assumed that this is encountered, if different stakeholders are actively (and controversially) engaged in a certain issue. In the following the transdisciplinary research approach gets analysed and discussed in the light of Mollinga's boundary work framework.

2.7.1 Learning from Transdisciplinary Research (TR)

While the ample range of processes and tools provided by IWRM, AM and EA may overstrain the user, be it the policy maker, scientist, or representative of civil society, in their search for decision support in water resources management, the research approach of Transdisciplinary Research may help to structure the management problem(s) to be addressed, define specific knowledge needs and support target oriented knowledge generation and problem solving. The Transdisciplinary Research approach provides operational guidance how to go over complex and contested natural resources management problems that require knowledge generation. As research model, it supports the better understanding of real-life problems in a structured manner and aims at developing practical solutions. Combining elements of IWRM, AM and EA through the methodology of transdisciplinary research acknowledges not only the complexity of the systems, but also supports problem and objective-oriented knowledge generation to foster decision making under uncertainty.

Approaching solutions for complex natural resources management problems requires inherently inter- and transdisciplinary research. Inter- and transdisciplinarity have been defined in multiple ways. In this study, interdisciplinarity is understood as 'cooperation across different academic disciplines', whereas transdisciplinarity implies 'incorporating knowledge from different actors, professionals as well as lay persons, to develop practical solutions to real-world problems.'

While interdisciplinarity tries to overcome barriers between academic disciplines, transdisciplinarity is inherently different. It addresses complex environmental and societal 'real-world' problems, aims for practical solutions and is based on the understanding that these problems cannot be solved by science alone. In addition to scientific knowledge it requires the integration of knowledge and perceptions of society. Natural resources management problems are furthermore not only 'environmental or technical problems' but also 'societal problems', dealing with questions on resources allocation and thus touching questions of fairness and equity. Research towards sustainable water resources management − as a highly contested arena − requires an approach that integrates society in problem and target definition as well as in the subsequent transformation process and that supports mediation between conflicting stakeholders and interests. Transdisciplinary Research can be defined as research that (Lawrence and Després 2004, Mollinga 2008a, Pohl 2005):

- Addresses problems characterised by complexity and heterogeneity;
- Is action – oriented;
- Tackles complexity in science and challenges knowledge fragmentation in disciplines; it sets aside the idealised context of science in order to produce practically relevant knowledge, transcending any academic disciplinary structure;
- Addresses both science's and society's diverse perceptions of a problem; it accepts local contexts and uncertainty; it is context specific negotiation of knowledge and requires close and continuous cooperation between experts and lay-persons during all phases of a research project;
- Addresses possible improvements of the status quo through balancing the diverse interests and inputs of individual stakeholders and disciplines.

Transdisciplinary Research can be regarded as an approach to study, promote and implement sustainable resources management and is oriented towards the common interest. Whereas IWRM, AM and EA provide major principles for WRM, the TR methodology may add operational guidance not to get lost in the ample range of proposed processes and tools from the three approaches when tackling a local WRM issue. It also provides support for the development of appropriate boundary objects as well as the reflection of boundary settings.

2.7.2 Transdisciplinarity, boundary concepts, objects and settings

Complex and contested situations of water resources management are mostly characterized by multiple (opposing) positions of a variety of stakeholders and societal, political or cognitive boundaries of various kinds between them. Facilitating collaborative decision-making and action requires a process that supports actively addressing and dissolving these boundaries. As explained above, the approach of Transdisciplinary Research as proposed by Pohl and Hirsch Hadorn (2007) may support the structured reduction of complexity and the development of balanced and tailored solutions (see also Mollinga 2010c, who exemplary thinks the approach through in the context of a water pollution and health research project in India).

TR has four underlying **principles** that shall support reduction of complexity (Pohl and Hirsch Hadorn, 2007: 20−22):

1. *Reduce complexity by specifying the need for knowledge and identifying those involved*
2. *Achieve effectiveness through contextualisation*
3. *Achieve integration through open encounters*
4. *Develop reflexivity through recursiveness*

Transdisciplinary Research is conducted in an inherently recursive procedure, i.e. it is based on an iterative process in which concepts and methods are repeatedly tested. This allows to test underlying principles, assumptions and approaches in 'real-life-experiments' and to adapt them, if it is found that they do not further reflect reality or are not anymore target oriented. So far these principles are also in line with the requirements of adaptive management, as described in Chapter 2.4.2. The Transdisciplinary Research process consists of three phases to be repeated over time (Pohl and Hirsch Hadorn 2007):

Phase 1 − Problem identification and problem structuring: It aims at reducing complexity by identifying the relevant actors, the prevailing problem and the corresponding framework conditions. To structure the problem, the main question has to be divided into sub-questions.

Phase 2 − Problem analysis: The sub-questions will be handled and answered in a reflexive procedure.

Phase 3 − Bringing results to fruition: is implemented during the course of the research process through continuous implementation of outcomes from Phase 2. Monitoring and evaluating the impacts of these activities allows for an interpretation, whether or not the research community is still on track to solve the prevailing problem.

And three kinds of knowledge are necessary to design the process (Hirsch Hadorn et al. 2008): **1) Systems knowledge** − knowledge about the genesis and possible development of a problem and about interpretations of the problem in the life-world; **2) Target knowledge** − knowledge to determine and explain the need for change, desired objectives or improved practices and **3) Transformation knowledge** − knowledge about technical, social, legal, cultural and other possible means of acting to transform existing practices and introduce desired ones.

Pohl and Hirsch Hadorn (2007) suggest different tools to put the four principles into practice. In the following, I reflect these in the context of the boundary work framework and complement them by insights, processes and tools from IWRM, AM and EA:

Problem identification, structuring and analysis, in the light of boundary work thinking, does imply to assess diverging concepts and core settings of stakeholders, as reasons or obstacles for collaboration. I refer to boundary concepts in terms of principles and terminology. Boundary settings are considered the internal and external framework conditions that shape the project and the problem. Revealing underlying principles of core actors and identifying the wording that requires a harmonised interpretation in the context of the specific boundary settings is directly linked to the first phases of development- and research projects. As suggested in TR, this covers **problem identification and problem structuring** as well as **problem analysis**.

Complexity shall be reduced by identifying the relevant actors, the core problem and knowledge needs as reflected by principle 1 (*'reduce complexity by specifying knowledge needs and the actors involved').* By working on the development of boundary concepts for the local problem, the core problem will be concretised. To allow implementation of principle 2 (*achieve effectiveness through contextualisation)* the corresponding framework conditions, thus the boundary settings, need to be analysed. The knowledge needs for this first step cover generation of **system knowledge** as well as **target knowledge**. Three tools suggested by TR can be used to support this first step (Table 2):

Table 2 Tool 1 − Identifying the actors involved with regard to transdisciplinary research requirements (Pohl and Hirsch Hadorn 2007: 30)

Actors involved / Requirements for TR	Actor A	Actor B	Actor…	Discipline A	Discipline B	Discipline…
Complexity of problems						
Diversity of perceptions						
Abstract and case-specific knowledge						
Knowledge and practices that promote what is perceived to be the common good						

As TR deals with problems that require knowledge generation, there will always be a 'research question'. This may be a new thought for the design of development projects that hardly merge implementation with research approaches. There may be a specific reluctance to acknowledge knowledge needs and uncertainty in the context of development projects that − depending on the philosophy of the funding agency – may be obliged to guarantee achieving pre-defined results and impacts. Three guiding questions are given by Pohl and Hirsch Hadorn (2007: 40) to reveal assumptions that guide the research:

1. To what understanding of the genesis and possible development of a problem and life-world interpretations of it does the research question refer?

2. To what kind of need for change, desired goals and better practices does the research question refer?

3. To what technical, social, cultural and other possible means of acting does the research question refer?

Table 3 Tool 2 − Positioning the need for knowledge with regard to the three forms of knowledge (Pohl and Hirsch Hadorn 2007: 40)

	Research Questions	Particular challenge	Questions to help with positioning
Systems knowledge	Questions about the genesis and possible development of a problem and about life-world interpretations of a problem	Reflecting on and dealing with uncertainties with the help of real-world experiments	2, 3
Target knowledge	Questions related to determining and explaining the need for change, desired goals and better practices	Clarifying and prioritising diverse perceptions of targets and values, taking into account the common good as a regulatory principle	1, 3
Transformation Knowledge	Questions about technical, social, cultural, legal and other possible means of acting to transform existing practices and introduce desired ones	Learning how to make existing technologies, regulations, and practices and power relations more flexible	1, 2

Tool 2 (Table 3) is originally meant to classify the type of TR according to the focus of knowledge needs. In the context of the boundary work framework – and aiming at developing instrumental work for action, thus boundary objects – I aim for developing transformation knowledge. However, to be able to develop tailor made boundary objects that support the transformation, first systems and target knowledge needs to be generated to ‘achieve effectiveness through contextualisation’.

Table 4 Tool 4 – Embedding transdisciplinary research in the life-world (Pohl and Hirsch Hadorn 2007: 65)

Questions about the impact model	Area of impact		
	Private sector	Civil society	Public agencies
What impact is intended?			
What existing needs, interest, technologies, regulations, practices and power relations need to be taken into account?			
What causal relationships are initially assumed?			
In what form and at what point in time can results be introduced in a way tailored for the target group?			
What are likely unintended impacts, and what 'probes' may reveal them?			

Tool 4 (Table 4) aims at embedding TR in the life-world. I suggest adding the following guiding questions: What is the concrete resources management problem to be addressed and how is it interpreted ('problem mapping')? Who are the main actors involved ('actor mapping')? What are the relationships, roles, responsibilities and power dynamics alike ('network mapping')? What are their perceptions and interests ('perception mapping')? What knowledge needs to be generated to approach the problem ('abstract and case-specific knowledge identification')? What generates the problem ('perception mapping')? What are the external and internal boundary settings (technical, social, legal, cultural, political)? Which modes of cooperation between different actors, thus boundary work processes, already exist? Which specific boundaries hamper problem solving?

Some further guiding questions to reveal target knowledge may be: What should be changed about the problem? Why should this be changed? What are the desired objectives?

An ample range of specific tools for these type of qualitative analyses is provided through the academic fields of social and political science and compiled at td-net[16] as well as complemented through IWRM, AM and EA. However, to be of effective use, the tools for analysis in specific local cases need to be selected and compiled according to a) the capacities and experiences of the staff involved in the project and b) the culture of the local people and their hierarchical and educational level. While e.g. 'actor mapping' and 'network mapping' are activities to identify the actors and their relationships, there are many different ways how to do this in the local context. In some cultures 'drawing and picturing exercises' in group work give a good insight about actors and relationships, however these exercises may be totally inappropriate in other cultures or at higher hierarchical levels that 'do not want to fool around by playing games' and prefer to give their perspectives and perceptions through one-by-one expert interviews. The above reflections are meant to provide general guidance, but the specific tools of use in the specific context need to be identified based on the culture, educational and hierarchical level of the interviewees.

'Bringing results to fruition' requires instrumental work for action, thus the development and use of tailored boundary objects. The development of boundary objects is closely linked to what in TR is considered as 'transformation knowledge'. Suitability of boundary objects needs to be considered in light of principle 2 ('*achieve effectiveness through contextualisation'*) and principle 3 (*'achieve integration through open encounters'*). Two tools suggested by TR (Tool 5 and Tool 3) can be assigned to be of use for this task (Table 5 and 6):

[16] <www.transdisciplinarity.ch>, viewed 28 May 2015.

Table 5 Tool 5 – Embedding transdisciplinary research in the scientific environment (Pohl and Hirsch Hadorn 2007: 67)

Strategic elements	Project phase		
	Problem identification and structuring	Problem analysis	Bringing results to fruition
Goals (scientific/science policy)			
Contents (State of the art in relevant disciplines/state of the art in transdisciplinary research/future research areas/need for institutional action)			
Addresses (disciplines/transdisciplinary groups/science policy actors)			
Forms (publications/organisations of conferences/initiation of research programmes/development of networks/writing of official statements)			

Table 6 Tool 3 – Forms of collaboration and modes of integration (Pohl and Hirsch Hadorn 2007: 59)

Modes of integration	Forms of collaboration		
	Common group learning (search for something new)	Negotiation among experts (give and take)	Integration by a leader (give or take)
Boundary object			
Glossary			
Everyday language			
Models			
Mutual adaptation of concepts			
Transfer of concepts			
Bridge concepts			

This distinguishes different forms of collaboration (common group learning, negotiation among experts and integration by leader), which supports the identification of suitable boundary objects according to the encountered form of collaboration in the specific context. However, the proposed 'modes of integration' cover a colourful mix of different ideas that could all be interpreted as boundary objects. It is proposed to structure the 'modes of integration' according to organisations, processes, tools and products, as discussed in Chapter 2.6. The identification of appropriate boundary objects needs to develop in a joint approach with the involved stakeholders. It is about prioritisation of possibilities that require different resources in terms of expertise and money. Some guiding questions to reveal transformation knowledge and define suitable boundary objects could be: Which devices and instruments are suitable to facilitate the desired transformation process? Which boundary objects are required and suitable to facilitate maximum change in a given time frame and with limited financial resources?

Principle 4 (*'develop reflexivity through recursiveness'*) characterizes an ideal for the process of TR (and thus boundary object itself) and also a precondition for adaptive management. It means the TR should be understood as iterative process in which in a structured learning cycle questions are asked and answered in a repeating procedure. There is no guidance given how to do this in practical terms. Of course, 'recursiveness' cannot be endlessly repeated and repetition will be limited by 'real-life' constraints in terms of budget and time. To apply this principle in boundary work processes will require further reflections.

2.7.3 Designing boundary work processes for real-life cases

Merging the steps of TR with proposed steps from AM and EA, I propose that a process to be followed when actively designing and approaching boundary work in real-life cases could be:

1. Identify core stakeholders and set-up a stakeholder team (ideally this comprises political decision makers, representatives from civil society and researchers); in a developmental context, this can further include representatives from international organisations;
2. Jointly identify, structure and analyse the problem(s) to be addressed in line with different stakeholder perceptions; this includes the basic identification of concepts and settings that hamper collaboration;
3. Define problem boundaries, objectives and intended impacts; Identify key uncertainties to achieve the impacts;
4. Develop shared boundary concepts and acknowledge boundary settings: develop a conceptual model that reflects a shared perception of the problem(s), the system in question within the identified boundaries including ecosystem goods and services and their importance for human well-being. Incorporate the reflection of key uncertainties. Specify a common perception of the 'external boundary settings' and how they may limit change or risk successful implementation;
5. Develop hypotheses about the impacts of different management actions in a) the light of different key uncertainties and b) their influence on ecosystem goods and services; choose ecosystem indicators;

6. Identify knowledge needs; design boundary objects suitable to generate and communicate developed knowledge. Boundary objects could also be 'management experiments/interventions' to test the hypotheses, as proposed in the adaptive management approach;
7. Implement the research and management interventions and develop a monitoring plan to measure the short- to medium- to long-term impact(s) of management interventions;
8. Evaluate the impacts in terms of management goals and hypotheses – if impacts can be noted within the project's life span;
9. Review results;
10. Reassess and adjust the problem definition, problem structuring and problem analysis, problem boundaries, objectives and intended impacts, the underlying conceptual model, the suitability of chosen boundary objects, planned interventions, and the monitoring plan.

2.8 Conclusions and Outlook

This chapter has presented an analysis of types of boundaries that characterise and challenge collaborative water resources management. Boundaries of importance are boundaries of scale, as well as boundaries between and within the four clusters of government, society (non-state or non-scientific actors)[17], science and international (donor) organisations. With the introduction into the scientific field of boundary work, and i.e. in the boundary work framework (concepts- objects- settings-framework) as developed by Mollinga (2008a, 2008b, 2010a), it has been shown that this framework can help to understand and approach these boundaries. Three leading approaches in water and natural resources management (i.e. Integrated Water Resources Management (GWP 2000), Adaptive Management (Medema and Jeffrey, 2005, Medema et al. 2008, Pahl-Wostl et al. 2007) and the Ecosystem Approach (United Nations

[17] While society in a general interpretation actually includes science and government, it is here used in a simplified understanding, referring to 'non-state' and 'non-scientific' actors.

1992) were analysed through the view of the framework, as basis to adapt the framework to the needs of water resources management. Further, the necessity to merge a water governance perspective into reflections on water resources management and boundary work was discussed. Based on the presented analyses, it was proposed to adapt the framework as follows: So far, the science of boundary work either focuses on the analysis and approach of science-science or science-policy interfaces or in general on the demarcation between 'science and non-science'. It was found, that for analysing water resources management challenges, this perspective needs to be broadened: boundaries that hamper collaborative water resources management generally exist between government, science and civil society. Effective collaboration requires a 'trialogue' between these stakeholder clusters. In the developing world, a fourth cluster and related boundaries requires attention: this relates to international organisations at various levels that shape the local discourse and situation. Barriers that hamper collaborative decision-making and action should be analysed on two levels: a) barriers between the four stakeholder clusters and b) barriers within each stakeholder-cluster.

Based on the analysis of the three approaches of Integrated Water Resources Management, Adaptive Management, and the Ecosystem Approach, a proposal was made on how to adapt the framework to the specific needs of water resources management and research. Thus, boundary concepts need to be analysed and shaped at two levels: **boundary concepts on terminology** and **boundary concepts on principles**. Merging the principles provided by the three leading approaches in natural resources management, the general proposal for a shared boundary concept in terms of principles for water resources management can be summarised as follows: Water resources planning and management should be based on an integration of water, land and all related resources. Their development and management shall integrate all concerned actors, stakeholders and sectors – be it experts or laypersons – and shall be based on catchment boundaries rather than administrative borders. It is important to acknowledge and consider uncertainties in understanding human-ecosystem behaviour. Acknowledging uncertainty and knowledge gaps requires merging management with research approaches and modes of 'structured learning'. These combined approaches need to be flexible enough to allow changing the course of action, if new knowledge is gained in the research process. Sustainable management of natural resources implies balancing the needs for human development with ecosystem health − or the use of natural resources with the protection of natural resources, based upon principles of fairness and equity, whereas the overarching principle for management of water and other natural resources is the aim for human well-being.

The notion of **boundary objects** is adapted by proposing to categorize them in terms of **organisations, processes, tools and products**. Mollinga's notion of **boundary settings** is kept, by dividing them into **'external' and 'internal'** boundary settings. Whereas internal settings are considered to partially be allowed to be changed, the external settings are rather considered as 'given'. Being aware of and acknowledging external settings, supports to identify limits and limitations for transformative change. In this context it is recommended to think through political regime aspects when designing management and research projects, as the type of political regime to some extent defines and confines how boundaries are constituted and can be dissolved.

This conceptual research was completed by an analysis of Transdisciplinary Research approaches (Lawrence and Després 2004, Mollinga 2008a, Pohl 2005, Pohl and Hirsch Hadorn 2007) through a boundary work perspective. Transdisciplinary Research supports to go over complex and contested 'real-life' problems in a structured manner and aims for the development of practical solutions. Based on the latter reflections, an interactive procedure to design and approach boundary work in water resources management and research is proposed.

Further research is now required to apply and reflect upon the suitability of the developed framework as well as the procedure to approach boundary work in 'real-life-problems'. It is recommended to do so through intensive case study research in different contexts. The common guiding questions could be:

- Is the framework in its current form helpful to reflect and communicate about barriers for collaborative water resources management and research in the developing world? How can it be improved?

- How can it be used to develop 'instrumental work for action', means boundary objects, to approach 'real-life problems' in the local context?

Case studies are conducted in many different scientific disciplines, such as environmental science, civil engineering, anthropology, management studies, psychology, medicine to list only a few. They are designed in multiple ways with different focuses, methods and perceptions. The only common understanding is that they are '*an empirical inquiry that investigates a contemporary problem within its real-life context. Understanding the problem and its solution requires integrating a myriad of mutually dependant variables or pieces of evidence that are likely to be gathered at least partially by personal observation.'* (Scholz and Tietje 2002: 9). Scholz and Tietje classify various types of case studies, depending on their design (holistic or embedded; single case or multiple cases), the motivation (intrinsic or instrumental), the epistemological status (exploratory, descriptive or explanatory), the purpose (research, teaching or action / application), the data used (quantitative or qualitative), the format (highly structured, short vignettes, unstructured or groundbreaking) and the synthesis (informal, empathic, intuitive, formative or method driven).

In line with this classification and based on the results of this study it is recommend that the case studies required in future research for applying and developing the framework and / or the interactive procedure should fall under the following categories:

Exploratory / experimental / interactive: Case and methodology are not specified in advance but are evolving during research in order to support the development of framework and procedure. The level of experimentation and / or interaction depends on scale and resources of the research.

Embedded: The case covers several units or objects of analysis, as required in complex and contested problems. Usually this implies incorporating qualitative as well as quantitative data, but it can also – as done in this study by working with grounded theory – purely cover qualitative research.

Single (intensive case study research): In order to scrutinize and develop the framework and / or the interactive methodology, intensive case study research of single cases is appropriate. Analyses at this stage should not focus on multiple cases or comparative studies. Single cases − intensively studied − can reveal in greater detail the strengths and weaknesses of the proposed framework and / or approach.

Intrinsic / Instrumental: The situation shall be studied due to intrinsic motivation of the researcher in a specific case and shall further serve as medium to reflect upon usefulness and suitability of the boundary work framework and / or the proposed approach in their current state.

Unstructured or groundbreaking cases: Due to the difficult framework conditions as often encountered in developing countries, such as a fragmented water sector, unclear roles and responsibilities of often competing organisations, lack of data, high fluctuation of staff, and others, case studies in the developing world can often be considered as either unstructured or groundbreaking. ‘Unstructured’ means that problems are not well ordered or defined and information is not available in a written or condensed manner. The problem is mostly contested and no ‘best solution’ is obvious. ‘Groundbreaking’ implies that little to nothing is known about the current situation and the boundary settings and no structured research has been done on this issue so far.

In line with the above categories, the following case study (Chapter 3) can be considered as exploratory, to a very limited extent interactive, purely based on qualitative methods, single / intensive, intrinsic as well as instrumental and unstructured as well as groundbreaking. By its design, the case study does not feature intensive action-research components or experiments, to test and apply the procedure as outlined in Chapter 2.7. However, the findings of the in–depth analysis of the local situation through a boundary work perspective also allows some insights into the appropriateness of the proposed approach, as well as recommendations for its further development.

3 EMPIRICAL RESEARCH: BOUNDARY DYANMICS IN LOCAL WATER RESOURCES MANAGEMENT – A SOUTH AFRICAN CASE STUDY

Sub-questions II: The case study – applying the framework

How do modes of collaboration in local water resources management – hence processes of boundary work – function in selected river catchments (Swartvlei and Knysna Catchments) at the Garden Route region, South Africa? What hampers or supports collaborative decision making and action, in terms of boundary concepts, objects and settings?

How does the current real-life management approach as encountered at the study site play into striving for equity and sustainability – two core principles of South African Water Resources Management?

How could collaboration be improved, towards a more equitable and sustainable approach of water resources management?

Box 4 Sub-questions II: The case study – applying the framework

3.1 Introduction and Outline

South African water resource management is characterised by multiple stakeholders, diverse views, high political stakes in this mostly semiarid country, and mostly low decision agreement across the variety of actors. This is complemented through internationally advanced and sustainability oriented water policy and legislation that requires all stakeholders, as well as the public, to work on an integrated water resources management approach, based on participatory decision making. Implementing this ambitious goal in real-life still remains a major challenge (Schreiner and Hassan 2011, Schreiner 2013). The following research aims at analysing reasons and obstacles for collaborative water resources management through an empirical case study at the Garden Route region, South Africa.

The focus of this work is on understanding conceptual and structural barriers for collaboration of stakeholders in selected river catchments around the towns of Sedgefield and Knysna in the Eden District, Province of the Western Cape (WC), that are both locally recognized for facing and having faced diverse water challenges. The land use at the study site reflects a scattered mosaic of conservation areas, agriculture, forestry, relatively high class tourism (including golf courses and lifestyle farms) but also towns and townships that all imply different forms of water use. Over-usage of water resources as well as water pollution are defined as considerable problems while multiple actors from policy, science, the private sector and civil society show diverse interests in the use and management of the local water resources. The area has repeatedly suffered from floods, as well as a drought that lasted from 2009 – 2011, both still impacting on the ecological and socio-economic situation at the research site. Water resources management has yet hardly been coordinated among stakeholders, the water management approach remains fragmented and formal organisational models for joint and integrated water resources management, as required by South African water policy and legislation, were not yet in place. Especially this factual lack of an integrated water management approach was noted as major challenge for sustainable water resources management by various actors, as derived from the interviews.

The need for improved multi-agency cooperation has been clearly stipulated in the context of recent analysis on the precarious situation of South Africa's water resources (Roux et al. 2011). Conclusions specifically refer to the potential contribution of *'bridging agents to facilitate trust and relationship building and flows of knowledge across agency boundaries, including across science-implementation functions. (…). This promising but relatively new concept requires further exploration, for example to better understand the roles and responsibilities of bridging agents, factors influencing their legitimacy, their funding models, and how external or internal bridging agents compare.*' (Roux et al. 2011: n.p.). This clearly confirms the demand for local research in the scientific field of boundary work. The case study is outlined as follows:

Chapter 3.2 provides information on the ecological and socio-economic background at the study site, as basis for contextualising concepts, objects and settings. Chapter 3.3 outlines in detail the generic qualitative research methodology. Empirical research results are discussed in Chapters 3.4 – 3.7. Despite the high South African standards for integrated water resources management as required by national legislation and policy (the South African National Water Act, the Water Services Act as well as the National Water Resources Strategy) (outlined in Chapter 3.4.1), it was found that the local situation was characterized by three phenomena: fragmentation, exclusion and different dynamics of collaboration under stress. Societal and organisational fragmentation as characteristic feature of local WRM is in detail discussed in Chapter 3.5. It was further discovered, that the majority of poor, the so-called 'previously disadvantaged communities' were almost systematically excluded from water related decision-making. Chapter 3.6 thus discusses and reveals structural modes of exclusion of the poor in local water resources management, as well as the practices that lead to a production or reproduction of societal boundaries in the local context. Apart from water resources management under these 'normal' management circumstances, it was found that collaboration showed inherently different dynamics under emergency and water-stress, as encountered during the drought that lasted from 2009−2011. Stress based water related decision-making and collaboration are analysed in detail in Chapter 3.7. The concluding chapter (Chapter 3.8) summarises how the real-life situation, as discovered, works towards or against 'equity' and 'sustainability', two core principles of South African water policy and legislation, and outlines further research needs.[18]

3.2 Case Study Context

Water management problems play out in different spatial units (geographical, hydrological and administrative), mostly stretch over the multiple spheres of local, provincial and national government and change over time. They further cover religious, cultural, social (for example gender or racial based), political, financial, environmental, technical, legal as well as historical aspects. All these

[18] The core principles for South African Water resources management are equity, sustainability and also efficiency. This study is mainly focusing on the principles of 'equity' and 'sustainability', but reflecting challenges for efficiency, where applicable.

elements can constitute reasons, but also hindering factors for collaborative water resources management. Analysing modes of collaboration does not allow confining the research area by spatial boundaries. However, acknowledging the limitations of spatial classification for this type of research, a rough geographical orientation shall be given in the following section.

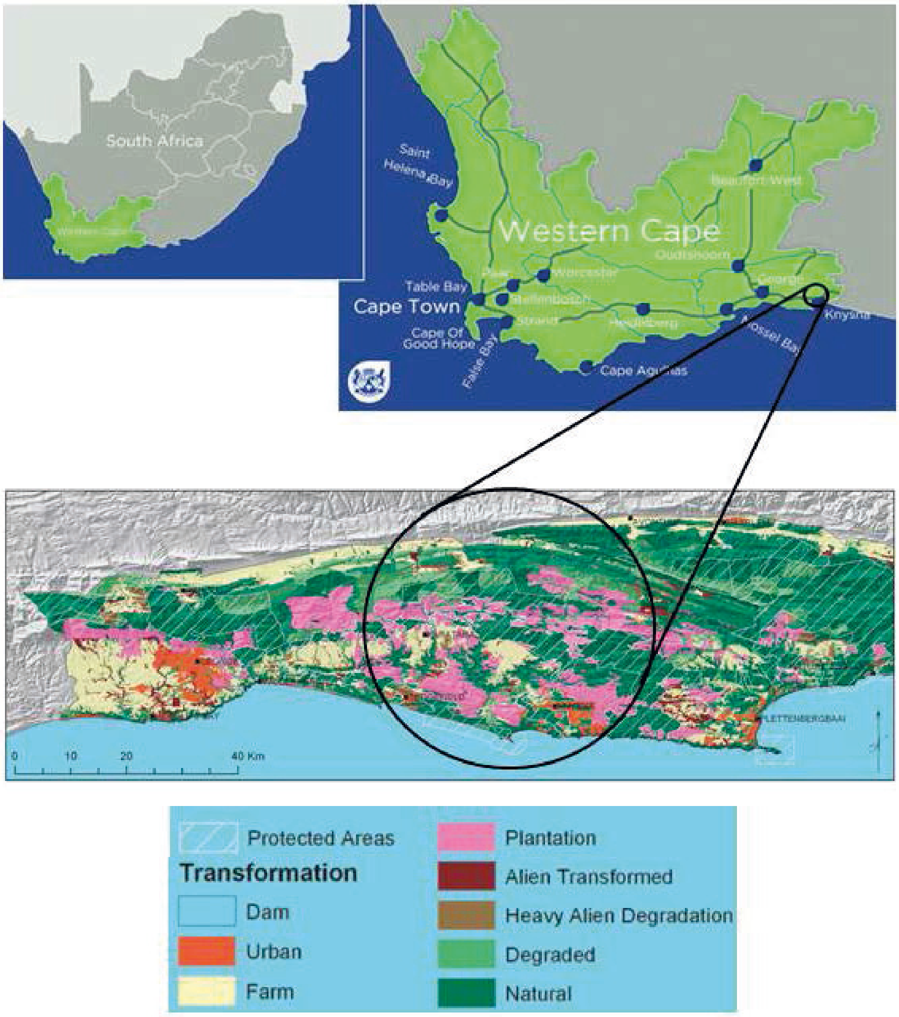


Figure 8 Location of the study site (marked by the author) and land cover (Western Cape Government 2014, Vromans et al. 2010a: 8)

The research addresses challenges for collaborative water resources management around the towns of Sedgefield and Knysna (Figure 8), which both fall under the local Municipality of Knysna, Eden District in the Province of the Western Cape, South Africa. The total population of Knysna Municipality was estimated to be approximately sixty nine thousand in 2011, with an average growth rate of 2.77 % between 2001 and 2011 (Knysna Municipality 2013: 36). The research area is with approximately 40 km * 30 km relatively small, which was required to reduce systems' complexity to be able to really delve in detail into the real-life challenges of collaborative water management on the ground. The site includes most of the quaternary river catchments named K40A−K40E as well as K50 A and B, which covers the rivers draining into the Sedgefield and the Knysna estuaries. The site stretches from about 1400 meters above sea level from the Outeniqua Mountains in the North, over approximately 30 km to the Indian Ocean in the South. The free-flowing nature of the rivers, thus the absence of in-stream dams, as well as the additional lack of off-channel water storage facilities constitute a challenge for town water supply, which is dependent on the rivers 'as they flow'. The estuaries are distinct in their ecological nature: the Sedgefield estuary is a temporarily closed estuary and prone to a flooding problematic, as people have settled in the flood plain. The Knysna estuary is permanently open with tidal influence and the ecologically driven discourse on water problems rather spins around pollution challenges.

The average annual rainfall is between 700 and 1200 mm, and the climate is mild (Eden District Municipality 2013: 52). The region was historically not considered to be at risk for droughts. However, huge in-migration over the last years paired with the shortfall of adapting water management to the increasing needs of a growing population has made the region prone to water scarcity now. This situation is further intensified based on noted challenges in operation and maintenance (O&M) of the existing town water supply systems, which at times reduces water availability due to technical failures (for example broken pumps) and high estimated water losses in storage and reticulation systems. Climate change is expected to further affect the region in different ways: global warming and sea-level rise are expected to endanger the coastline and settlements, and the area will further be more prone to erratic climatic events, which includes high rainfall as well as periods of drought (Eden District Municipality 2013: 54).

The area covers a scattered mosaic of different forms of landuse and economic activities (Vromans et al. 2010b): the steep mountainous areas are characterised by a mixture of commercial forestry and numerous separated conservation areas that form part of the Garden Route National Park. The plateau below is mainly used for farming activities, which covers dairy farming, but also fruit and vegetable production. Historically, the primary economic driver in the region was agriculture, with timber production, but the sector is declining for various reasons. Among others, land became highly expensive, which makes it almost not viable for commercial farming. This has resulted in subdivision of farms into smaller portions, evolving 'lifestyle or hobby farms' and the lack of 'emerging farmers' from previously disadvantaged communities. This explains why despite the farming sector being of crucial importance when analysing water resources management challenges in other South African regions, the agricultural sector was of less importance for this particular study. Knysnas' economy is meanwhile strongly based around tourism, which includes high class tourism and sports facilities, such as golf courses and related water needs. During high season in December and January the population figures double to triple, which tremendously challenges the municipal town water supply during this dry time of the year.

The research site is characterized by a high cultural diversity, with three of the eleven national languages being dominant, namely Afrikaans, Xhosa and English. Data quality, especially with regard to demographic and economic data, is regarded as questionable (Knysna Municipality 2013: 125), nevertheless, under acknowledgment of the noted limitations, available figures will be presented in this study: approximately 41 %, thus the largest population group, are part of the 'Coloured' population, 36 % are estimated to be 'black African', 21 % are 'White', and 2 % 'Asian or other'[19] (Statistics South Africa 2011). The

[19] The conventional South African classification of population groups according to their skin colour or race, into black African, Coloured, White, Indian/Asian and others is (still) a dominating feature of local statistics, concepts, language and discourse. These population groups are locally clearly distinguished, and the respective categorization reflects a 'normal', societally accepted and shared categorisation. In connection to the local culture, this terminology is applied in this study, despite this terminology not being perceived as impartial by the researcher. In its 'normal' use and application it is considered by the researcher as supporting and manifesting a practice of fragmentation and segregation.

research area is further marked by an extreme income inequality of the population. Income inequality in South Africa, with a Gini coefficient between 0,65 and 0,69 is among the highest worldwide and is considered to be a key challenge for development (Statistics South Africa 2014: 13, 36).[20] Data availability on the Gini-coefficient at local level is very scarce, and the range of available figures varied between 0,56 (Knysna Municipality 2013: 36) to over 0,70 (Dewar 2010: 12). In any way it is very high. The extreme inequalities at the research site are visible through poverty and unemployment in the townships and rural areas next to high-class tourism (golf courses and holiday resorts), which is imposing huge challenges for societal development and security. Poverty and unemployment are defined as reasons for increasing crime levels in Knysna (Knysna Municipality 2012a: 19−20).

3.3 Empirical Methodology

This chapter explains in detail the qualitative research methodology that has been applied to derive empirical as well as conceptual insights. The research is purely based on a set of qualitative methods. As the methodological approach evolved during field research in adaptation to the local circumstances and in an iterative process of data collection and analysis, the following chapter also includes personal methodological reflections, thus parts are formulated in 'first person'.

The research process started with the assessment of water conflicts and controversies that had occurred in the research area during the last fifteen years. This was the period defined by the actors, in which water issues started to become of importance and presence in local awareness. Based on the identified main water management challenges, a detailed assessment of stakeholders involved in the conflicts or people affected by the issues was conducted and

[20] The Gini coefficient is a commonly used index, reflecting the income distribution, or income (in-)equality within a nation. It can range between zero and one: A Gini coefficient of zero reflects perfect income equality, with all citizens earning having the same income; a Gini coefficient of one expresses highest possible inequality, thus one or few people receiving all the nation's income, and the rest of the population having no income.

entry routes to these groups developed. This was followed by an analysis of stakeholders' perspectives, concepts, perceptions of the problem, motivation to change something about it and their role in the processes of problem solving (revealing boundary concepts of stakeholders). In line with concepts and methods from transdisciplinary research (Hirsch Hadorn et al. 2008, Max-Neef 2005, Pohl and Hirsch Hadorn 2007), the stakeholders assessed represented all societal spheres (policy, science as well as civil society) and explicitly covered the perspectives of experts as well as laypersons. The analysis of actual decision-making processes revealed insights about existence and functionality of local boundary objects. Boundary settings were discovered through assessing dynamics of decision-making processes, following the questions of key enabling or limiting factors for collaboration around selected water management challenges.

Research process and guiding questions for the empirical assessment (Interviews, group discussions, observations and collection of secondary data):

- **Starting point:** assessing conflicts / issues / controversies /challenges around water management and sustainable development in the research area that had occurred during the last fifteen years: Which specific WRM conflicts and challenges for sustainable development characterise the area?
- **Detailed assessment of stakeholders** involved in the conflicts or people affected by the issues and identification of entry routes: Who are the interested and / or affected parties (I&AP) for each conflict or challenge? How can they be accessed? Are they organised, if so how / by whom? If they are not formally organised, how can they be accessed?
- **Analysis of stakeholder perspectives:** What are the stakeholders' concepts and perceptions of the problem, motivation to change something, and role? What is the public discourse around the problem? Where and how does this show (e.g. public media, events, court cases)? ***– reveals boundary concepts***
- **Decision-making or deliberation process:** By whom and how are / were problems approached and resolved (if so)? Who is included / excluded in the process and why? What were dynamics of these processes? – ***reveals boundary objects***
- **Framework conditions:** What enabled / enables or limits collaboration around the specific issue? Assessment of legal, political, institutional, social, cultural arrangements – ***reveals boundary setting****s*
- **Water resources management principles:** How does the current 're-al-life management approach' work towards or against the South African core principles of equity and sustainability?

Box 5 Research process and guiding questions

3.3.1 Data collection and documentation

Data assessment and analysis are based on a set of methods from qualitative research. This covered the conduction of in-depth interviews, focus group discussions, participant observation as ‘complete observer’ or ‘observer as participant’ in public participation processes and in societal and political events around water resources management and sustainability. It further covered the implementation of presentations and two feed-back workshops with core stakeholders, discussing and deepening preliminary findings of the research. Documentation of events (interviews, group discussions, observations) was done through audio recording, partial transcriptions and / or the development of detailed field notes on content, context, setting and procedure of the event.

Primary data collection was supplemented through an ample range of secondary data. This included the compilation of formal and informal background information on local water and development challenges as well as dynamics of processes of collaboration. This covered reports and communications from public libraries, municipal archives, newspaper archives, private archives of members of the local water forums, the Knysna Environmental Forum, of current and former governmental employees as well as individuals of relevance.

Primary data collection through approximately hundred forty documented ‘events’:

- In-depth interviews with key stakeholders (77)
- Informal talks with key stakeholders (18)
- Focus group discussions (11)
- Participant observation in social and political events around WRM and sustainability: in local forums of relevance (water forums, environmental forum), in public participation processes implemented by the local government (Municipal Integrated Development Planning, Ward committee meetings, Council meetings), in public participation processes organised by key actors, such as the Department of Water and Sanitation, at local markets, at community engagement processes, such as marches etc. (33)
- Organisation of feed-back workshops on preliminary results with key stakeholders (2) *(cont).*

Documentation of these 'events' through audio files, partial transcriptions and/or field notes on context, setting and procedure of selected events.

Collection of secondary back-up data (formal and informal background information):

- Reports from municipal archives and libraries
- Documentation of local forums of relevance, affecting water management, or being affected by the way the water resources are managed, i.e. the Wilderness Lakes Catchment Management forum, the Knysna Catchment Management Forum, the Knysna Environmental Forum, the Sedgefield Ratepayers and Voters Association (SRVA). This documentation is incomplete, as nothing has been archived in a structured manner, and some folders with past documentation have been destroyed. However, available information has been scanned and coded. It partly covers mandates, constitutions, Minutes of Meetings, correspondence with other stakeholders etc.
- Collection of private archives (correspondence of Ex-Politicians, Disaster Managers' Unit of the District Municipality etc.)
- Legal background documents, socio-economic background documents
- Collection of documentation around infrastructure development proposals of relevance in the context of local WRM (developments below the flood line – being affected by flooding, developments that were stopped due to arguments around limited municipal capacities for water supply and wastewater treatment, developments of water infrastructure (dams, boreholes, desalination plants, wastewater treatment plants etc., partially blocked, partially implemented) *(cont)*

- Newspaper data base: For the time of ten months all local newspapers covering the research area were screened on a weekly basis for articles dealing with: water related concerns, sector involvement of the key sectors regarding the management and use of local water resources (i.e. forestry, farming, nature conservation, tourism), as well as articles revealing local concepts of poverty, wealth, equity, sustainable development as well as local politics. The newspaper articles have been scanned and coded with maximum four codes each and comprise an own secondary data base.

Box 6 Qualitative data assessment and data base

3.3.2 Sampling structural diversity

Access through participant observation: As mentioned before, data assessment started through searching for and participating in selected 'instructive events', in terms of local phenomena, processes, examples or happenings that somehow related to questions of water use and management, and / or local challenges for equity and sustainability in a wider sense. The events were identified through screening the local press for announcements or following word-of-mouth marketing. This covered e.g. visits of local markets, which served to establish contacts to the local farming community, poorer township citizens and immigrants from other African countries, who are sellers at the market. Observations further covered governmental planning processes, organized by the Department of Water and Sanitation or district or local Municipalities. All these activities served to develop access routes and relationships to a broad range of stakeholders, to be able to gather a variety of voices to assess reasons and obstacles for collaborative, equitable and sustainable water resources management.

Searching for opposing positions: The methodological approach to diversify sources of information further included reflecting after each interview (formal or informal), which group of people would probably take up an opposite stance on what was just discussed with the previous interviewee, and to try to develop access to these (opposing) groups of stakeholders. After developing multiple entry routes to a great variety of stakeholders, snowball sampling was conducted to gather access to further peers of interviewees.

Searching for the 'unheard' – access to 'previously disadvantaged communities': Compared to the long list of local stakeholders that were revealed through research – and further relatively easy to access – one societal group seemed consequently invisible or underrepresented in processes of local water related decision-making, but of great importance when assessing reasons or obstacles for collaborative local water resources management, equity and sustainability. This refers to the economic 'bottom end' of this extreme societal dichotomy, i.e. the very poor, mainly living in townships and rural areas.

The poorer communities, also called the 'previously disadvantaged communities', are very large in numbers, strong in stakes regarding questions of water use, equity and sustainability, but very small in formal representation and participation.

Gathering point-source information proofed to be a challenge, as there were very little pre-established entry routes that would allow an unbiased perception of me and my research. This was further challenged by the fact that 'the poorer communities' themselves are a culturally extremely rich and heterogeneous group of people which required the development of multiple entry routes to cover a variety of different societal groups that are almost impossible to cluster societally in any way. This finding imposed challenges on the research: How to develop entry routes and access to the people that are not represented or visible in public debates? How to gather their perspectives? How to cluster and approach the 'unheard' and 'invisible'? Entry routes to gather the voice of the previously disadvantaged communities had to be developed in creative time-consuming ways, and the approach – as methodological result in its own right – shall be explained in greater detail:

Pre-established entry routes to poorer communities existed through the local government structures, Ward committees and the IDP processes, but Ward committees as well as Municipal structures were in principal perceived critically by the local communities and trust into governmental structures and employees was relatively low. Associating through political and governmental processes and structures was one of the followed entry routes, but it was necessary to access people also through other channels, to gain trust by the local people. The research site was further marked by a great scarcity of local or international Civil Society Organisations (CSO) or Non-Governmental Organisations (NGO) that worked with the poorer communities. Some initiatives organised soup kitchens for communities, and this served as entry route, but the approach remained scattered. The enormous variety of an uncountable number of different local religious groups hampered an easy and representative access through the local churches, but was nevertheless followed to gain access to some extent.

The above described challenges in gathering access to the societally heterogeneous and culturally rich group of the 'previously disadvantaged communities' required creativity and time, was lengthy and cumbersome, covered the search for different approaches and entry routes and also included several 'dead ends', where initiated collaboration did not further materialise. However, due to the long period of the third field research period of 10 months, some successful collaboration could be established and the following research routes were developed:

Route 1 – Access through established collaboration through existing (governmental) initiatives: The research covered assessment, participation and observations in different governmentally driven processes and initiatives that were designed to address the needs and perspectives of the previously disadvantaged communities and related to water and / or sustainable development. This covered local Working for Water programmes, the 'Knysna River Health Project' and the 'Khayalethu River Project', Integrated Development Planning (IDP) workshops on district and municipal level, Council and Ward committee meetings, the Community Development Workers Programme (CDWP) and the Department of Water and Sanitation's participatory process to gather feed-back of local communities with regard to the National Water Resources Strategy II (NWRSA II).

Route 2 – Access through local farmers markets and arts and crafts markets: This route supported a superficial access to immigrants from other African countries who were active sellers at local markets, who were not visible in any debate – but actively engaged in the grey economy and contributed through their activities to the local lifestyle.

Route 3 – Access through tourism: Formalised, governmentally or politically driven processes did not allow interacting with local communities without being associated with the organisers. As trust in the government was in principal rather low, it was required to develop alternative approaches to speak to local community members. Accessing the local townships through tourism activities allowed to be seen as 'tourist' and 'foreigner'. This supported to be looked at less through a racial, historical or otherwise politically influenced perspective. Being pregnant further (unintended) supported to quickly mingle with the local women, and almost always provided for a first friendly and ice-breaking talk about pregnancy, family and other topics that rather focused on commonalities than differences. This allowed developing a first personal impression of each other.

- **Booking a township tour:** Broad access to local communities was started and further developed through booking one of the multiple township tours that had been promoted by Knysna Tourism.[21] I decided to book with a female operator (assuming that personally connecting to her would be easier), with the worst marketing (hoping for authenticity and less commercially influenced involvement), with no car (driving with my own car, but also walking through the township, thus being among the people and not staring at local living conditions through the window of a mini-van). In total – I was looking for someone rather conducting fewer tours who would (hopefully) have time and no fixed programme, to be free to jointly develop the day without being hampered by other tourists. I booked as 'tourist' and not as researcher, and let the following developments emerge, based on the impressions gained during the day. This route proofed to be the most successful and after the first tour we decided to start a research collaboration and I outsourced some re-

[21] <www.knysnalivinglocal.co.za/> and <www.knysnalivinglocal.co.za/community-experiences/dining-experiences/34-sister-food.html>, viewed 28 May 2015.

search activities to the tour operator. The woman since then supported me as research facilitator in the township.

- **Overnight stay in the township:** Access through tourism was complemented through staying overnight in a Bed and Breakfast (B&B) in the local Rastafarian community (Judah's Square) and getting introduced to the organised Rastafarian community in the area. This was important, as the Rastafarian community is relatively well established, has good access to services, in terms of roads, water, sanitation and electricity, and is actively engaging in tourism as well as conservation oriented initiatives.

Route 4 – Working with local research facilitators: Through the first township tour I had developed a contact to two women: the tour operator (as described above) and her friend, who was joining us for the day. In the following I worked with both women as local research facilitators for different activities: The tour operator, who knew the local communities very well and was active at numerous levels as local facilitator, since then supported my research through commissioned and specifically designed township tours. Several township tours were in the following conducted for different local Wards, which reflects an administrative subdivision of local Municipalities into smaller electoral areas or 'sub-communities'. Scaled township tours addressed the following topics for the visited areas: the dominating local culture, the main religious groupings as secondary entry points, and the general housing and water and sanitation situation in the area. The facilitator further arranged some interviews with local religious leaders of the visited area. If interest was stipulated by the religious leaders, this was followed up through the organisation of group discussions with the congregation. Preparation of group discussions was quite time consuming and not always successful, and in the end five group talks could be implemented. Group discussions were pre-announced, either conducted in connection with a church service – or alternatively started with a joint prayer − and were translated either through the research facilitator or the religious leaders. The research facilitator usually accommodated the social gatherings through simple catering.

The other research facilitator – a local Ngoma (healer), also highly educated in conventional science and further multi-lingual, initiated a small study for me, how to societally cluster the local townships and also conducted transcriptions and translations for me. Apart from the research facilitators I worked with research assistants from SANParks and the local University, making sure that they represented different genders and cultural groups (Black, Coloured, White, male and female, speaking different languages). They supported translations during events and were further requested to document the events through their perspectives, taking notes on contents, procedure and dynamics of the event and jointly discussing our perspectives after the event. Including their view in the analysis of events was assuring to avoid (own) circular logic, blind spots or unintended simplistic (mis-) interpretation.

Research in the townships was guided by the following principles:

Legitimacy: It was of utmost importance to have legitimacy and an atmosphere of mutual respect for each other when conducting group talks or interviews, to allow for creative and open-minded exchange – in order to avoid to be faced with provocative arguments or expectations, as often encountered in governmentally driven processes. For this reason it was good to be introduced and backed-up by local religious leaders.

Time and flexibility: A pre-condition to allow for research in the townships was to bring time and flexibility and give room for 'windows of opportunity'. This allowed accommodating (spontaneous but important) encounters and happenings. It was important not to dominate the day driven by own intentions and time-plans, but to let go and deviate from original plans and let local realities steer the day. This allowed me to visit homes, see living conditions and spontaneously talk to important locals, which otherwise would not have been possible.

Transparency, openness and expectation management: Any interaction across such cultural and economic divides, between a (wealthy) foreigner and economically disadvantaged groups is partially embedded in the hope to receive financial support. In group talks and interviews I always stipulated that I had no financial means to support the local community now or in the future, but that I am here with time and interest to listen and communicate their needs and perspectives through my research. I further explained that I however had no idea, if at all, and when my words would influence anything. People appreciated this approach, and explicitly appreciated the dedication of time and attention. Not raising false expectations is a primer and a moral obligation when collaborating across such an economic divide.

Personal security: Accommodating time and flexibility had to be balanced with assuring personal security. But also this was quite straight being supported and thought through by the local communities, when organising and facilitating events and interviews.

3.3.3 Data analysis

Data analysis was conducted by enquiring selected primary and secondary data with support of atlas.ti, a software for qualitative data analysis, by applying concepts and methods from Grounded Theory (Glaser and Strauss 2009, Charmaz 2006). Grounded Theory may be defined as: '*the discovery of theory from data − systematically obtained and analysed in social research' (*Glaser and Strauss 2009: 1). The analysis of data was conducted through an iterative procedure of coding and grouping of codes and documents, writing memos, and re-coding / grouping of codes and documents. This served a) to develop hypotheses and theories about reasons and obstacles for collaborative WRM, equity and sustainability in the case study context and b) to derive conceptual insights to develop the boundary work framework in a grounded manner.

The analysis mainly focused on primary data and was complemented through secondary data. Primary documents were in a first round all renamed, so that the title of the documents contained information on the date of the event, the type of data collection (semistructured interview (INT) or informal interview (INT IF), focus group discussion (FGD), participant observation (PO) in the role of complete observer (CO) or observer as participant (OP), feed-back workshop (WS)), and key information on the interviewees (name) and the sector they represented e.g. stakeholder from the conservation sector (CONS), farming (FAR), forestry (FOR), community (COM), Municipality (MUN), the research site (Sedgefield (SED) or Knysna (KNY)) and contents.

Different projects were developed in atlas.ti: The core project contained all – but only – primary data, thus transcriptions, field notes, pictures and others. The analysis of primary data was started by creating twenty two document families, one for each emerging group of stakeholders, to later identify and extract the core stakeholders for the research area. Other (separate) projects were developed in atlas.ti over time, containing secondary data in line with different lines of research. Despite the software to be specifically developed for qualitative analysis at large scales, it was found to ease the complex process of data analysis by strictly separating primary and secondary data sources in separate projects.

Data analysis covered deductive and inductive coding procedures: **Deductive coding** initially followed the three key elements of the boundary work framework by coding **'boundary concepts'** of actors, identifying **'boundary objects'** for local decision-making and coding **'boundary settings'** of actors and decision making processes. The subsequent development of sub-codes for each category allowed conceptual insights on developing the framework further. Deductive coding further focused on the notions of **'Equity'** and **'Sustainability'**, as core principles for local water resources management. At a later stage, deductive coding further followed the emerging phenomena of local collaboration (or the lack thereof) of **fragmentation**, **exclusion** and **emergency management**.

The analysis was in parallel following **inductive coding** procedures, which supported the development of structural phenomena as well as narratives that unpacked reasons or hindering factors for collaborative water management in a more comprehensive and groundbreaking sense. Main codes and code families that developed through the inductive coding procedure e.g. cover: issues, actors, processes, dynamics, politics, relationships, and respective sub-codes – and had revealed the core phenomena of fragmentation, exclusion and emergency management.

3.3.4 Research ethics and research principles

Water resources management is a contested arena, were diverging interests, power plays and informal ways of decision-making characterise planning and management realities. Thus, research on collaboration in water resources management is highly political and data assessment must follow high ethical standards, to avoid negative impacts on individuals who had provided data and information. Three key principles were followed: a) the development of trust and relationships to the stakeholders, through long-term presence and personal involvement in the research area, b) providing full transparency about the research set-up, funding sources for the research, and handling of data c) the guarantee that data itself as well as the sources for the data are fully protected and treated with highest confidentiality.

3.4 Boundary Work in South African Water Resources Management

Empirical research revealed a great difference between the theoretical approach to facilitate sustainable and equitable water resources management, as outlined through national policy and legislation (the South African National Water Act, the Water Services Act as well as the National Water Resources Strategy), and the reality of planning and decision-making on the ground.

3.4.1 Planning the ideality: The water resources management framework

The basis for the South African water resources management framework is provided through the Constitution (Act 108 of 1996) by assigning to everyone the right to have access to sufficient food and water (Republic of South Africa 1996: s 27) and to an environment that is not harmful to health or well-being of the population and that gets protected, for the benefit of present and future generations, through legislation and other measures (Republic of South Africa 1996: s 24). The hydro-institutional[22] landscape in South Africa can be

[22] The term ‚institution‘ is in this empirical study applied in analogy to the local (South African) use and application, meaning ‘actors’, ‘players’ or ‘organisations’, and not, as in the Study of Social Sciences typical, in terms of ‘rules’, or ‘*the humanly devised constraints that structure human interaction*’ (North 1994: 360). The usual scientific distinction between ‘institutions’ and ‘organisations’ (North 1990, 1994) is not applied in the empirical study, to keep the terminology close to the local norm and terminology, as also non-scientific stakeholders are one target group of this study.

structured according to the governmental spheres of the national, provincial and local level. The core organisation on national and provincial level responsible for water resources management is the Department of Water and Sanitation (DWS) under the Ministry for Water and Sanitation.[23] Several other governmental departments also impact on water resources management through their (sometimes conflicting) policy mandates. This refers to the Department for Environmental Affairs, the Department of Agriculture, Forestry and Fisheries and the Department of Cooperative Governance and Traditional Affairs (formerly the Department of Provincial and Local Government).

The Minister of Water and Sanitation acts as public trustee of the country's water resources, thus he/she has the authority over the nation's water resources and must ensure that '*water is allocated equitable (fairly) and used beneficially in the public interest (especially towards those who have not benefited in the past), while also protecting the environment.'* (Department Water Affairs and Forestry n.d.a: 12). The overall responsibility to manage the nation's water resources is thus assigned to National Government, whereas it is the responsibility of local Governments, to provide water and sanitation services to the population (potable water supply systems, domestic waste-water and sewage disposal systems). These responsibilities are translated into two legal Acts: the National Water Act (36 of 1998) (Republic of South Africa 1998a), addressing water resources management (surface and groundwater) under the main responsibility of National Government, and the Water Services Act (108 of 1997) (Republic of South Africa 1997a), providing rules on provision of water and sanitation services to municipal users, under responsibility of local municipalities as water service providers. The new National Water Act was drafted in 1998 and has substituted the old Water Act from 1956 (Repub-

---

23 Due to ongoing governmental restructuring procedures, DWS changed its name between 2009 and 2015 twice, from Department of Water Affairs and Forestry (DWAF), to Department of Water Affairs (DWA) to now the Department of Water and Sanitation (DWS). In this study, the different names will be used in analogy. Previously integrated into the Ministry of Environmental Affairs, it is since 2014 also the new Ministry of Water and Sanitation, with three top functions: the Minister and the Deputy Minister of the Ministry of Water and Sanitation, and the Director General of the Department of Water and Sanitation. <www.dwa.gov.za/default.aspx>, viewed 13 May 2015.

lic of South Africa 1956). The old Water Act had assured riparian water rights to private landowners and respectively excluded the majority of the population from access to water resources, as they were no land owners. In line with the White Paper on Water Policy (Republic of South Africa 1997b), the new Water Act redressed this right, and now assures equal access to water to everyone.

Further, also the National Environmental Management Act (NEMA) (No. 107 of 1998) (Republic of South Africa 1998b) regulates water and environmental affairs, by requiring the establishment of environmental management plans as well as environment implementation plans. These Acts – although shaping the legal boundary settings for South African water resources management, are considered as not harmonised. National water legislation and policy are further complemented through the Strategic Framework for Water Services (2003), the National Water Resources Strategy I and II and Water Services Regulations (following the Council for Scientific and Industrial Research (CSIR) 2010, Roux et al. 2008 and Simpungwe 2006).

The National Water Act (NWA) (Republic of South Africa 1998) defines the core settings for South African water resources management, by outlining concepts in terms of management objectives and management principles and by defining boundary objects as tools to achieve the management objectives, through strategies and institutions / organisations. The NWA shall ensure that South Africa's water resources are '*protected, developed, conserved, used, controlled and managed'* (Republic of South Africa 1998: Chapter 1) which reflects a boundary concept in terms of 'management objectives'. These objectives shall be achieved by applying the core principles of sustainability, equity and efficiency. The boundary concepts are further defined in terms of 'management principles' as follows (Table 7).

Table 7 Boundary concepts in terms of management principles (Department Water Affairs and Forestry n.d.a: 11)

<table>
<tr><td colspan="2">PRINCIPLES OF THE NATIONAL WATER ACT:
Sustainability, equity and efficiency are the principles that guide the protection, use, development, conservation, management and control of water resources.</td></tr>
<tr><td>Sustainability means promoting social and economic development and at the same time ensuring that the environment is protected both now and for the future. The environment needs to be protected because it is where water comes from. If there is a good balance between using and protecting water resources then current and future water needs can be met.</td><td rowspan="3">Sustainability, equity and efficiency recognise:
- the basic human needs of present and future generations,
- the need to redress (correct) past discrimination,
- the need to protect water resources,
- the need to share water resources with other countries,
- the need to promote social and economic development through the use of water,
- the need to establish representative water management institutions, and
- the need to ensure participation of stakeholders and users in decisions that affect them.</td></tr>
<tr><td>Equity means that everyone must have access to water and to the benefits of using water. Decisions to allocate water must be equitable (fair) to all people.</td></tr>
<tr><td>Efficiency means that water should not be wasted. Water must be used to the best possible social and economic advantage.</td></tr>
</table>

The NWA further provides two additional principles that shall function as boundary concepts: integration and participation. ‘Integration’ is defined as ‘*coordinated planning and management of water, land and environmental resources’*, requiring cooperation and coordination between stakeholders, and *‘participation of people in decision-making where decisions are decentralised.’* (Department Water Affairs and Forestry n.d.a: 15) Public participation is of utmost importance in the new Water Act of 1998, redressing failures of the old Water Act, drafted in 1956, which was characterised by a centralised and authoritarian water resources management approach (Department Water Affairs and Forestry n.d.a: 9). Participation shall be enabled at the lowest (decentralised) possible level, which shall be facilitated through the development of new water management institutions at regional and local scale. These institutions shall be representative and facilitate participation of local communities and other stakeholders.

To facilitate achievement of the management objectives, specific boundary objects are outlined at three distinct tiers. Each tier defines specific bridging agents or boundary organisations, and provides further tools in terms of strategies or management activities that are under the responsibility of the responsible organisation. Following the Department Water Affairs and Forestry (n.d.b: 6−8), the tiers are as follows:

First tier: The first tier reflects the national level, and here the Ministry and the Department for Water and Sanitation: the Minister of Water and Sanitation holds the overall responsibility for water resources management and the Department of Water and Sanitation administers the Water Act on behalf of the Minister. Planning and management of the national water resources shall be implemented in line with the National Water Resources Strategy (NWRS), as national boundary object. The NWRS, at a strategic level, outlines shared boundary concepts and boundary objects.

The purpose of the NWRS as boundary object is to:

- *'facilitate the proper management of the nation's water resources,*
- *provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole,*
- *provide a framework within which water will be managed at regional or catchment level, in defined water management areas,*
- *provide information about all aspects of water resource management,*
- *identify water-related development opportunities and constraints.'*

The NWRS must:

- *'Set out strategies, objectives, plans, guidelines and procedures for the overall management of the national water resource*
- *Determine how much water must be 'reserved' for basic human needs and for the environment (called the Reserve)*
- *Provide for international obligations (water resources shared with neighbouring countries through international agreements)*
- *Provide for future water needs*
- *Provide for water for strategic use (for example national power generation)*
- *Determine water management areas*
- *Determine how much water is available in each water management area*
- *Provide for transfer of water from water management areas that have surpluses to water management areas that are short of water*
- *Set principles for water conservation and water use*
- *Set targets for water quality for different water resources*
- *Provide for the establishment of water resource management institutions (for example catchment management agencies) and the interrelationships between these institutions (co-operative governance).'*

Box 7 Boundary concepts on management objectives and management principles as defined by the National Water Resources Strategy (Department Water Affairs and Forestry n.d.a: 13)

The NWRS progressively evolves after public consultation and is reviewed every five years. All water management institutions (WMI) and strategies at lower level must be in line with the NWRS. As long as lower levels of water management institutions are not yet operational, the Department is responsible for administering the Water Act and to fulfil all functions and duties of the (still lacking) decentralised water management institutions. It is foreseen that the Department's role in line with progressing delegation of powers to the regional and local level shall change, to increasingly focus on national water policies, a regulatory framework and also on monitoring, support and control of WMI.

The only rights to water, as provided by the NWA, are water for basic human needs, which is accounted for through the 'Basic Human Needs Reserve' (drinking water, water for preparation of food and for personal hygiene) and water, in sufficient quantity and quality, which is allocated to ensure environmental integrity through the 'Ecological Reserve'. The Basic Human Needs Reserve and the Ecological Reserve (together called 'the Reserve') must be assured and protected. Further, water for strategic use, for instance national power generation, and also water assigned through treaties and agreements to neighbouring countries, shall be reserved. Only 'surplus' water can be allocated to different (local) water users, which is the core objective of the second tier (see below). However, in order to know how much water can be allocated to local water users, it needs to be thoroughly assessed, how much water in which quality is available, and then strategically decided, how much water and in which quality needs to be reserved, to cater for human needs and the ecology. To balance between protection and use of water resources, different mechanisms are under development: the classification of major river systems, assessing the current state of the river in terms of water quantity and quality, and outlining a desired future state. The decision on the desired future state provides the basis of future allocation of water to local users. Local development objectives for sustainable development, embracing ecological, economic and social thinking, must be in line with the permitted water use, as defined by the river class. Thus stakeholder consultation is of high importance in decision-making on the determination of the future class of the rivers, however, the ultimate (strategic) decision, on classification of rivers and respective setting of the reserve for each significant water resource and related catchment lies with the Minister of Water and Sanitation. The core mechanisms to achieve the balance between protection and use of the water resources are defining the river class, setting the reserve and regulating and controlling the water use. In order to cater for proper water control and compliance monitoring, it is thus outlined, which type of water use requires registration and / or licensing. (Department Water Affairs and Forestry n.d.a).

Second tier: The second tier reflects water management at larger catchment levels, in line with nine defined Water Management Areas (WMA), which shall each be managed by a Catchment Management Agency (CMA). Whereas previously the country had been divided into nineteen WMAs, in the revised NWRS II it was proposed to consolidate into nine WMA (Figure 9), acknowledging limitations in capacities, skills and expertise as well as funding, to effectively get nineteen CMAs operational.[24]

[24] Currently two CMA have been established, and the country faces considerable challenges in getting this decentralised water management level to function.

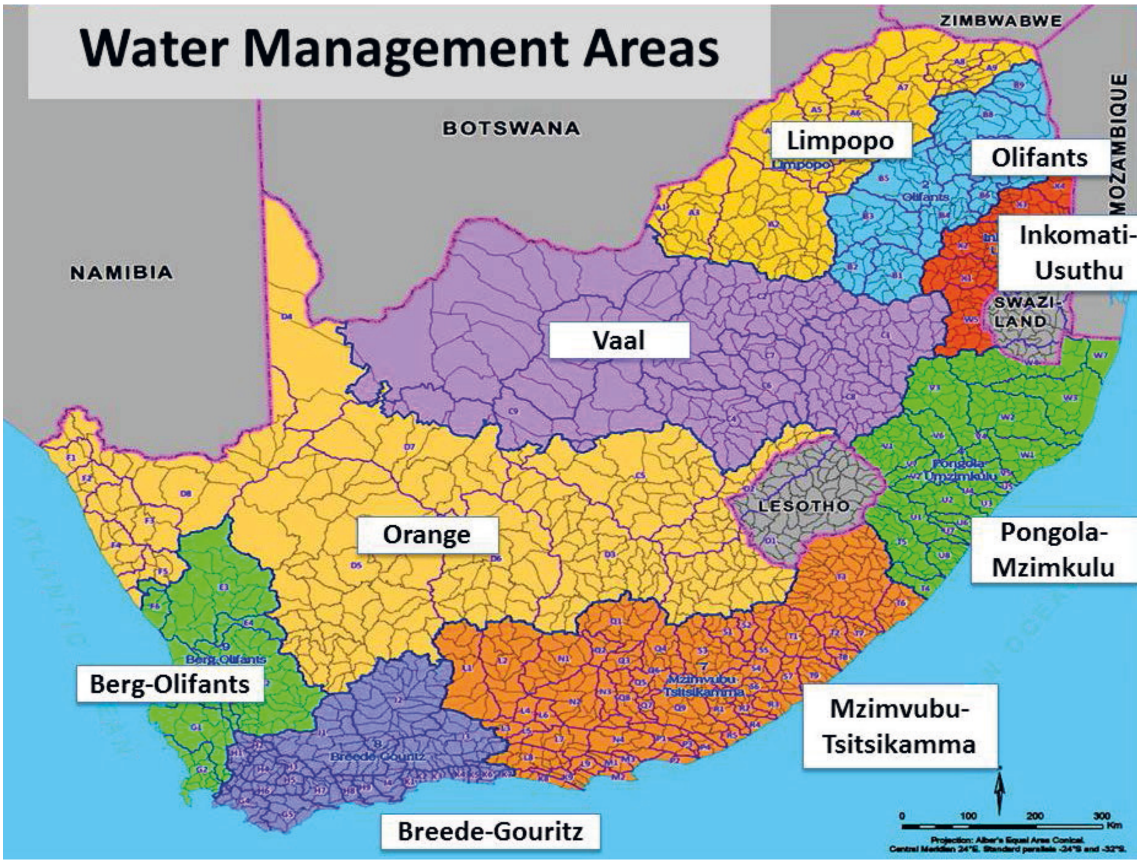


Figure 9 Nine (new) water management areas (Department Water Affairs 2012a: 17)

Water resources management at catchment scale shall be facilitated through the participatory development of Catchment Management Strategies (CMS) for each of the nine WMA. The Catchment Management Strategies provide the framework for water resources management within the WMA, they shall guide the way how other, further decentralised WMI in the water management area can or should support the work of the CMA. The CMS shall put a particular emphasis on water allocation between competing water users. The allocatable amount of water is defined after the reserve has been set by National Government.

The purpose of the catchment management strategy as boundary object at WMA level is to:

- *‘set principles for allocating water to existing and new water users*
- *provide the framework for managing water resources within the water management area*
- *ensure that water resources in the water management area are protected, used, developed, conserved, managed and controlled.’*

The catchment management strategy must:

- *‘take into account the classification of water resources and water resource quality objectives and the requirements of the Reserve and international obligations*
- *set out strategies, objectives, plans, guidelines and procedures for the overall management of water resources within the water management area*
- *contain a water allocation plan according to a set of principles*
- *take into account national and regional plans (prepared under any other law) including the water services development plans (WSDPs) of municipalities*
- *enable public participation in managing the water resources in the water management area*
- *take into account the needs and expectations of current users and potential users.’*

Box 8 Boundary concepts on management objectives and management principles as defined by Catchment Management Strategies (Department Water Affairs and Forestry n.d.a: 16)

Third Tier: The third tier reflects the local level, as decentralised as possible, represented through Water User Associations (WUA). WUAs can take over responsibilities for water management activities at local level, if delegated to the WUA by the CMA.

Purpose and functions of a Water User Association as boundary object:
*'The **purpose** of a WUA is to enable water users to co-operate and pool their resources (financial, human resources and expertise) to more effectively carry out water-related activities.*
*The **functions** of a WUA depend on its approved constitution and the purpose for which it was established. The constitution of a WUA could provide for the following the functions to be performed by the WUA:*

- *to prevent water from any water resource being wasted*
- *to protect water resources*
- *to prevent any unlawful water use or acts that negatively impact on the water resource*
- *to generally supervise the water resources*
- *to regulate the flow of any watercourse*
- *to investigate water quality and water use*
- *to construct and operate and maintain waterworks for draining land or supplying water.'*

Box 9 Boundary concepts on management objectives and management principles of Water User Associations (Department Water Affairs and Forestry n.d.a: 39)

Other bodies provided for through the Act are bodies responsible for international water resources management and advisory committees on specific topics.

Non-statutory bodies: Apart from these statutory bodies also non-statutory bodies can support the CMA. This refers to Catchment Steering Committees and Catchment Management Forums: Catchment Steering Committees represent all core stakeholders during the establishment process of CMAs, and are usually dissolved after establishment of the CMA. The roles assigned to Catchment Forums have changed over time, and remain vague; however they reflect the highest level of decentralisation, as, in contrary to WUAs, they are the only institutional body that allows anyone who shares an interest in the water resources, to participate in local water resources management and get involved, not only particular water users, such as farmers, municipality or else:

‘*Catchment forums provide an institutional mechanism to facilitate ongoing participation of stakeholders with diverse interests. A catchment forum gains its strength from the stakeholders it represents, rather than statutory powers. A key purpose of a catchment forum is to enable the public (anyone) to participate meaningfully in water resources management. They also provide an important platform for stakeholders to share their views and to communicate with the CMA. The ongoing role of catchment forums is as important, if not more important, than their role during the CMA establishment process.’* (Department Water Affairs and Forestry n.d.b: 23). Catchment Forums shall be as representative as possible, and it shall be ensured, that ‘*activities aimed at stakeholder identification and involvement are not limited to existing water user associations or user groups. A key area of focus is the need to ensure the involvement of previously disadvantaged groups in the entire process (of forum establishment).’* (Department Water Affairs and Forestry 2001: para 2.2.4) The roles assigned to catchment management forums (CMF) can be facilitating consultation, institutional development, institutional coordination and supporting CMA in water resources management activities.

'A catchment forum may have one or more of the following responsibilities:

- *disseminate information about WRM in the WMA to the public;*
- *consult stakeholders on the formulation of a vision for the water management area (WMA), the development of a CMS or the evolving nature and functions of a CMA;*
- *advocate on behalf of stakeholders with DWAF (Department of Water Affairs and Forestry), the CMA and other organisations;*
- *build capacity of stakeholders and groups around WRM (institutional development), focusing on previously disadvantaged groups; facilitate the participation of stakeholders in the development of a CMS and other WRM activities;*
- *foster cooperative governance, particularly between WMIs and local government;*
- *coordinate the strategies and activities of various bodies, to foster cooperation;*
- *monitor water resources and/or users to identify problems;*
- *advise on WRM decisions, by making recommendations to the relevant WMI; and*
- *perform WRM activities (although a forum is not necessarily the most appropriate body for this type of function).'*

Box 10 Boundary concept on potential management objectives of Catchment Management Forums (Department Water Affairs and Forestry 2001: para 4.2.2)

3.4.2 Facing the reality: Fragmentation, exclusion and emergencies

Despite the above described high South African standards and excellent framework for integrated water resources management, it was found that the local situation looked inherently different. The hydro-organisational landscape at local level at the research site was de facto relatively simple: The Department of Water and Sanitation and the Eden District Municipality (EDM) shared a strategic and oversight-role on different levels, whereas the District Municipality was further responsible for disaster management, i.e. droughts and floods. Neither a catchment management agency nor a water user association was in place during data assessment, thus the DWA was in charge to also fulfil the tasks of a CMA. Due to organisational restructuring, the research area has recently been incorporated in the water management area of the Breede-Gouritz Catchment Management Agency, and is thus now covered by a CMA. Collaborative action initiated by the CMA still has to be evaluated in future.

The local Municipality of Knysna acts as water service provider. Two catchment management forums, as non-statutory bodies for water resources management, exist in the research area: the Wilderness Lakes Catchment Management Forum (WLCMF) and the Knysna Catchment Management Forum (KCMF). These forums meet on a regular basis, discuss and address water related issues but have no decision-making power.

Other governmental players, such as the Department of Environmental Affairs, Forestry and Fisheries, were not directly visible or involved in decision-making at local level around water resources management, but South Africa National Parks (SANParks) − as parastatal organisation reporting to the Department of Environmental Affairs − was present and active. Water-related businesses, such as farming, forestry or tourism were visible and engaged at different scales, depending on their individual interests. This local setting was completed by a variety of additional groups, associations and very vocal and active individuals that addressed specific water issues of relevance by their private means and efforts.

Despite a discourse on public participation and integration, water resources management was factually characterised by three core phenomena: fragmentation, exclusion and different dynamics under stress. These phenomena constituted distinct challenges for equity and sustainability in local water resources management:

Finding 1 − Fragmentation: Under normal circumstances, water resources management was marked by fragmentation of stakeholders and local initiatives. The research had revealed an extreme patchiness of water related issues, concepts and engagement processes that – although ecologically and socio-economically interrelated – were not looked at and approached in an integrated manner. Each stakeholder perceived different water management challenges as core problem. A common problem statement, vision or management objective was lacking, and collaboration of actors in terms of boundary objects circled in numerous separated initiatives around topics of individual concern only. It was not possible under normal management circumstances, to identify one core water issue around which collaboration would bridge between the majority of stakeholders or to identify core boundary objects that would serve to actively bridge across the diversity of stakeholders. This will be unpacked in detail in Chapter 3.5.

Finding 2 – Exclusion: South African water policy and legislation are geared by the moral commitment to redress equity for the entire population in both, access to water as well as the benefits received from water. Public participation to work towards this ambitious goal is of utmost importance. The normal management situation at the study site however was characterised by almost systematic exclusion of 'previously disadvantaged communities', thus the majority of the poor in local water and sustainability related decision making. Especially the key principle of 'equity' was challenged by the encountered realities. The numerous local initiatives around different water issues almost all shared one common feature: structural absence of the previously disadvantaged – in participation as well as in acknowledgement of their specific needs. Studying and understanding this phenomenon in greater detail required intensive engagement and creativity to develop entry routes to poor and excluded communities, to build up trust and relationships to reveal their positions, as well as reasons for the absence in local decision-making. The results are discussed in Chapter 3.6.

Finding 3 – Emergency: The region had repeatedly suffered from floods, as well as a drought and empirical research revealed that formal and informal collaboration of stakeholders under water stress showed inherently different characteristics than the management approaches under normal circumstances. In Chapter 3.7 it will be presented and discussed, how water stress in terms of a drought influenced water related decision-making and how the consequences of decision-making under pressure impact on sustainable water resources management in the long-term.

3.5 Fragmentation: The Normal Incident

This chapter unpacks the phenomenon of fragmentation in local water resources management through discussing how the lack of proper functioning boundary objects, and especially the lack of shared concepts and supportive settings hampers boundary crossing and collaborative action. The research process had started with screening water management challenges and conflicts that had emerged at the research site during the last fifteen years. Before that time water challenges were less in the local focus. Persisting water conflicts and management challenges during that period cover water allocation between different users (farming, forestry, conservation / national parks, golf courses and town water supply), legal aspects and compliance monitoring, disaster management (floods and a drought), town water supply (equitable access and assuring short-, medium- and long-term town water supply, including operation and maintenance challenges), water pollution and in principal the lack of an integrated management perspective. The analysis of the local water resources management challenges showed a great diversity of concepts, actors interested in or affected by the issues and activities to approach the problems. It was found that stakeholders generally focused on selected issues of individual concern only and tried to approach this concern with their individual and very different means. The analysis revealed that fragmentation was manifested through diverging concepts of stakeholders regarding a) the actual problem definition and respective management objectives as well as b) management principles that should be applied in a management approach and further the organisational or individual settings under which the stakeholders operate. The diversity of concepts regarding local water resources management challenges and the diverging objectives of each actor, based on their organizational settings, constituted a core obstacle for collaboration.

3.5.1 The practice of fragmentation: Scattered boundary objects

Unpacking reasons and obstacles for collaborative water resources management required in the first instance a problem as well as stakeholder assessment. As outlined in the previous chapter, the key stakeholders, regarding the use and management of the local water resources in the research area, were the following:

- **Government:** Department of Water and Sanitation, Eden District Municipality, Knysna Municipality
- **Parastatal:** South Africa National Parks
- **Forums / Associations:** Knysna Catchment Management Forum, Wilderness Lakes Catchment Management Forum
- **Business:** Farming, Forestry, Tourism, Infrastructure Developers and Investors, Consultants in the field of infrastructure developments (water and others) as well as spatial planning and environmental impact assessments.
- **Previously disadvantaged communities**

Collaboration happened in multiple scattered approaches around selected issues of concern, but in no integrated or coordinated manner. There were no obviously functioning 'boundary objects' in place that would span over a variety of (conflicting) stakeholders and that would facilitate bridging across the broad range of water conflicts or management challenges. Most bridging agents would only bridge across stakeholders with regard to very selected specific topics of individual concern. The only bridging agent, that to some extent facilitated exchange across a broader range of stakeholders were the two local catchment management forums. Further, numerous processes of public participation, information and stakeholder consultation relating to water resources management and / or (sustainable) development planning had been implemented over the past years, but also in a rather scattered approach. This for instance covers information and stakeholder consultation in the context of:

- the 'Outeniqua Reserve Determination Study', implemented by the Department of Water Affairs and a consulting company,
- Integrated Development Planning at district level
- Integrated Development Planning at Municipal and Ward Level
- Environmental Impact Assessments (EIA) for proposed Infrastructure Developments

Although public participation processes as outlined through the water resources management framework can serve as boundary object, there were no processes in place that really facilitated an integration of all the perspectives as required and outlined in the water resources management framework. Water was further not in the focus of local development planning, as other local needs were more pressing. Further it was noted, that stakeholder engagement did only to a limited extend include the majority of the previously disadvantaged communities, despite this being of high importance. The lack of visible and functioning boundary objects can be explained, by fragmentation of stakeholders in terms of concepts and settings.

3.5.2 Drivers of fragmentation: Concepts and settings

Data analysis revealed that one reason for the lack of collaborative action was the diversity of concepts of local core stakeholders. Diverging concepts that hampered collaboration played out in different categories: this covered diverging perceptions on the actual problem definition for local water resources management, respective diversity of concepts regarding the management objectives, and further differing concepts on management principles. The empirical results regarding conceptual fragmentation, as derived through analysing interviews, group discussions and observations, can be summarised as follows (Table 8):

Table 8 Stakeholders and their concepts in local water resources management

Stakeholder	**Core concepts on 'problem statement' and respective 'management objectives'**	**Core concepts on 'management principles'** ***(cont)***
Government		
Department: Water and Sanitation	- Lack of integrated and strategic water planning - The reserve determination - Functional water management institutions (i.e. a CMA) - No proper allocation between different users (farming, golf courses, the municipality, (direct abstraction from the rivers), forestry by contributing to a streamflow-reduction activity, and nature, through its own right for water as assigned by the 'ecological reserve' *('We don't know, what we manage')* - No resources for adequate registration of water use, water licensing, compliance monitoring - Extensive red tape, hindering effectiveness - No resources for adequate support of local Municipalities - No resources for adequate support of local communities	- Integrated water resources management - Equity, sustainability and efficiency in water resources management (although diverging concepts were associated by different employees with the same terms)

Stakeholder	Core concepts on 'problem statement' and respective 'management objectives'	Core concepts on 'management principles' *(cont)*
Eden District Municipality	- Disaster management: drought management (of relevance for both, Knysna and Sedgefield) and flood management and prevention (mostly relevant for Sedgefield)	- Fulfil legal requirements - Strategic / integrated development planning on district level; support local development
Municipality of Knysna	- Town water supply (access, short-, medium- and long-term) - Technical municipal challenges (lack of capacities for leak detection and repair and proper O&M of water and wastewater systems) - Water pollution at the Knysna estuary	- Fulfil legal requirements - Strategic / integrated development planning on municipal level; support local development - Get re-elected
Parastatal		
SANParks	- Water pollution (Knysna estuary) - Flooding at Sedgefield: disaster management and prevention - Infrastructure developments in the buffer zones of the rivers and below a 1:100 year flood line	- Conservation outcome

Stakeholder	Core concepts on 'problem statement' and respective 'management objectives'	Core concepts on 'management principles' *(cont)*
Forums		
Catchment Management Forums	- Water pollution at the Knysna estuary - Flooding at Sedgefield: disaster management and prevention - Town water supply (short-, medium and long-term) - Technical municipal challenges	- Diverging principles
Previously Disadvantaged Communities		
Different clusters	- Fulfilment of the basic needs - Housing and related access to services, including water supply and sanitation - Job creation - Personal security	- Equity - Fulfilment of the basic needs
Businesses[25]		
Farming[26]	Diverging concepts on problem statement, management objectives (allocation, abstraction, flooding, pollution, legal aspects) and management principles depending on farm location and farm sizes, access to water / existing water rights, network, and the individual worldview of the farmer.	

[25] These businesses were identified as closely related to questions of water management and sustainability and thus are mentioned here. However, they all had in common that no shared concepts could be derived per sector or business group. Concepts strongly depended on the individual setting of the company.

[26] Considering limitations in data availability and data quality, and a noted lack of water monitoring and control, the main water user in the research area allegedly is the local

Stakeholder	Core concepts on 'problem statement' and respective 'management objectives'	Core concepts on 'management principles' *(cont)*
Forestry	Diverging concepts on problem statement, management objectives and management principles, depending on company size, history, network and existing water rights. Concepts varied between large scale forestry (CapePine, former MTO), medium scale (PG Bison) as well individual small-scale foresters and covered allocation issues, as well as extensive legal problems with planting permits and licensing procedures. Large-scale forestry mainly argued with SANParks over areas that should be handed over from forestry to conservation, thus potentially influencing water availability in the catchments through different water consumption patterns from commercial alien vegetation compared to indigenous forest. Small-sale forestry had partially severely battled with DWA regarding planting permits and licensing procedures.	
Tourism	Diverging concepts, circling around water availability and pollution concerns.	
Infrastructure Developers and Investors	Diverging concepts relating to individual development projects and their specific water and wastewater problems. Problem statements circled around environmental and (land) politics, spatial development planning, and limited municipal capacities to cater for additional developments in terms of water supply and wastewater treatment.	

Municipality, followed by the industrial sector, and last agriculture (and not – as in many other South African regions – the agricultural sector) (Knysna Municipality 2013: 44–45).

Stakeholder	Core concepts on 'problem statement' and respective 'management objectives'	Core concepts on 'management principles'
Consultants (Companies and Individuals)	Companies and individual (freelance) consultants had specific influence, if they were involved in the field of infrastructure developments (water and others) as well as spatial planning and environmental impact assessments: The consulting sector influenced local decision-making through studies investigating options for water and wastewater infrastructure, studies on environmental impacts of proposed infrastructure and studies on spatial development planning. Shared concepts could not be derived but varied between consultants, also depending on the size and power of the company and topics addressed.	

Some concepts are shared across some actors, but no concept, regarding the actual problem statements, management objectives, or management principles, span across all or even just a few actors. It was further noted that especially the principles of 'equity' and 'sustainability', as proclaimed by national water policy and legislation, did not function as boundary concepts but were interpreted in numerous, even contradicting ways. The lack of integrated action can be interpreted as based on the lack of proper functioning boundary concepts on core problems, objectives as well as management principles.

Diverging concepts as well as the level of engagement of stakeholders were strongly influenced by the organisational or individual settings of the stakeholders and played out through real encounters. The external settings, in terms of legislative or constitutional mandates of organisations defined roles and responsibilities of stakeholders in theory, as well as available resources in terms of finance and staffing. The way how organisations and individuals then actually perceived and performed their daily duties further depended on the factual internal organisational settings, in terms of staffing, management style and individual concept and motivation. Concepts further were influenced by settings in terms of technical or natural elements. Settings in terms of technical elements refer to infrastructure and technology that shape the local water supply and wastewater management situation. Natural elements are ecological settings that are constituted by nature, as e.g. the topography, climate, and rainfall patterns that influence concepts and the local reality and discourse.

In the following, it will be discussed for selected stakeholders, how specific settings either constitute the basis for diverging concepts or further demonstrate important reasons for lack of collaborative action. This will be highlighted through discussing real encounters and clash of concepts, as encountered at the study site.

The Department of Water and Sanitation: The role of the Department of Water and Sanitation (DWS), is defined through constitutional and legislative settings. Of importance for local water resources management are the following mandates, during the time of research outlined by the Department Water Affairs (2012b: 20) as follows:

'*The Constitution of the Republic of South Africa (…):*

- *Gives municipalities executive authority and the right to administer the provision of water services within their areas of jurisdiction*
- *Gives national and provincial government authority to regulate local government in terms of water services*
- *Gives national and provincial government the obligation to support and strengthen the capacity of local government to provide services (…)*

The Department's legislative mandate is to ensure that the country's water resources are protected, managed, used, developed, conserved and controlled, by regulating and supporting the delivery of effective water supply and sanitation'. (…) The Department's core functions are: policy formulation, water resources planning and management, water resources infrastructure development, capacity building, intergovernmental and intra-sectoral co-ordination, water services support, water resources and water services regulation.' (Department Water Affairs 2012b: 20)

The self-perceived role of the Department of Water and Sanitation at local level, partially in line with this, but further shaped by own institutional and local settings, was as follows: responsibility for strategic water planning, the support and control of water users and the water service provider (Knysna Municipality), and following up on legal aspects, as e.g. registration of water use, licensing and compliance monitoring. This role was based on the lack of a Catchment Management Agency during time of the research, who should eventually take over some of these responsibilities and the respective role of DWS to fulfil also the role of other water management institutions. However, despite these concepts, factual involvement in the research area by the Department was low, which was mainly explained by very limited capacities of the Department to involve on local level as well as geographical distance, with responsible staff being stationed in Cape Town, which is about five hundred kilometres away from the research site. The Department was perceived by local stakeholders as 'purely reactive – never proactive', and blamed for only getting involved, if persisting complaints about water problems, as e.g. illegal abstraction or pollution incidents would reach the Department.

Fulfilling the Department's strategic and oversight role as well as following up on legal aspects seemed to be challenged by the total lack of resources in terms of staff, and further hampered by the lack of data in quality and quantity regarding actual registered water use in the research area as well as proper abstraction figures. Farmers, foresters, municipality and consultants described the situation of the core data base for registered water use, the Water Authorisation and Registration Management System (WARMS) as inscrutable, which made any compliance monitoring almost impossible. Farmers and foresters further described the process for registering water use and obtaining water licenses as lengthy and stated that handling of applications by the Department could take up to seven years. The process would further be handled in such inefficient and intransparent manner, that some individuals preferred to pay external consultants with in-house knowledge and connections to the Department to process and follow up on pending applications to speed up the process.

The chaotic situation of the data base for registered water use was further confirmed by the Department through interviews *(*in summary: *'we don't know, what we manage')* and in numerous reports. This includes e.g. the Department's 'Town Water Reconciliation Strategies' for Knysna, Sedgefield, Rheenendal and Karatara. For Knysna it is stated that *'permitted abstraction and WARMS registration don't match'* and that *'license status and conditions for all water resources need to be clarified'* (Department Water Affairs 2010a: 8). For Sedgefield it is noted that *'(Water) registration and use don't match'* (Department Water Affairs 2010b: 7). Also for Rheenendal and Karatara, the rural areas of the Municipality, the registered water use remains fuzzy (Department of Water Affairs 2010c: 5, 2010d: 5). The mismatch between Municipal data and DWA's data was confirmed in the Bulk Water Supply Planning Study (Knysna Municipality 2007: 15-16). Without proper information on registered water use as well as actual abstraction figures, there is limited possibility for the Department to fulfil its strategic and oversight role. Interviewees from the Department clearly confirmed that the Department has no resources for proactive and strategic water resources management and proper compliance monitoring at local level, and that effectiveness to fulfil their mandate would in addition further be considerably hampered by red tape. This situation was complemented by the lack of other functioning organisational bodies that would be able to take over these responsibilities.

Another impinging setting, hampering effective registration of water use, compliance monitoring or providing practical support at local level was the noted 'red tape', an idiom for complex and time consuming governmental or administrative procedures. Red tape provides the setting for related fear of officials to take decisions without being in a position to document or assure that these decisions were in line with all (potentially unknown) legal requirements. Red tape, allegedly hampering not only DWA's (now DWS) effectiveness, is well-known in South Africa to an extent that there even is a specific Red Tape Reduction Unit at the Western Cape Province[27] including the Western Cape Red Tape Call Centre[28]. One case was assessed at the research site, were the Red Tape Reduction Unit got involved with DWA: DWS did not want to grant a license to a small scale forester, despite not having any legal basis to reject the

27 <www.westerncape.gov.za/redtapereduction/>, viewed 28 May 2015.

28 <www.westerncape.gov.za/news/western-cape-red-tape-call-centre-resolves-89-all-calls-logged>, viewed 28 May 2015.

application. Whereas DWA had already conducted many mistakes during the application procedure, the process was further effectively hampered by red tape over several years. Due to strong persistence of the small-scale enterprise, their very well-organised documentation of the whole application procedure, related red tape and mistakes by DWA, and finally due to the involvement of the red tape reduction unit, the license in the end was granted. However, financial losses of the forester over several years, also based on the fact that DWA had cut down their trees without a proper legal basis for that action, were not redressed.

Whereas the WARMS data base was not considered to be in good order, DWA was busy with the preliminary reserve determination, which is a highly complex task. In this regard it was noted that local water users, represented by the catchment management forums, had little understanding on the implications of the so far ‘preliminary reserve’ on their daily management practice. CMF representatives wanted to learn about the implications of the reserve for allocation of local water use, and practical management consequences that should follow the reserve determination and had asked DWA for support in this regard, but this knowledge gap could not be closed during time of data collection. It however seems impossible to address allocation issues at the local level for DWA or a CMA, as consequence of the reserve determination and the setting of the river class, if there is no accurate or even contradicting information on registered water use at local level, and little knowledge on actual abstraction figures.

Another organisational setting in hindering the proper fulfilment of the Departments’ roles and responsibilities was further defined as the great loss of experienced staff and knowledge after the end of apartheid. Highly knowledgeable staff, that was politically further not acceptable, was substituted by a majority of less experienced younger − but politically acceptable − employees. For the younger employees however, working for the Department of Water and Sanitation in many cases served and still serves as step towards a job at another organisation, who appreciates knowledge, skills and network as developed under the Department – and who apparently would pay considerably higher salaries. This covers local Municipalities, (who often get criticised for their high payment schemes especially for management staff), as well as companies from the private sector. The high fluctuation of less experienced but relatively expensive young employees, who are politically accepted, seems to constitute a structural obstacle for the Department to properly fulfil its mandate.

Eden District Municipality: According to the NWRS II: '*Water resources planning must be integrated into national, provincial and local planning and must be addressed in all growth and development strategies.*' (Department Water Affairs 2013: 6, 49). Roles, responsibilities and functions, constituting the legal settings of the District Municipalities are outlined in the Municipal Structures Act, Act 117 of 1998 (Local Government 1998). Thus the district Municipality has among other liabilities the responsibility for the implementation of Integrated Development Planning (IDP) on district level, including the strategic oversight role for Integrated Development Planning on municipal level. Whereas Core strategy No 2 of the National Water Resources Strategy II requires that Integrated Development Planning and decision-making should be centred on water resources management, alignment between water resources planning and local development planning, as aimed for by the Department of Water and Sanitation, was not schematised.

The challenges at district level covered a variety of social development complexities, including the need for job creation and poverty alleviation, local economic development, challenges in the health-, transportation- and education sectors, infrastructure challenges and many more. Further the district Municipality was challenged by limited income sources and high dependency on government grants (Eden District Municipality 2013). The vision of addressing complex district challenges in the context of strategic water resources planning does make sense in a theoretical socio-ecological systems perspective. Realisation of this ambitious principal however at district and local municipal level was however not possible, taking into account the real-life settings, in terms of resources and capacities.

Apart from the strategic oversight role, the district municipality is further responsible for disaster management. This function is mandated in the Disaster Management Act, Act 57 of 2002 (Republic of South Africa 2002), the National

Disaster Management Framework (Republic of South Africa 2005) and the Municipal Systems Act, Act 32 of 2000 (Republic of South Africa 2000) and disaster management constituted a key performance area of the District Municipality (Eden District Municipality 2012: 159−160, 2013: 59−60, 77) The main natural disasters in the district are fires and flooding. From 2009 – 2011 the district was further challenged by a drought, followed again by extreme flooding events during 2011, which were both classified as 'local disasters' (Eden District Municipality 2012: 117). Thus during times of emergency the District Municipality functions as bridging agent between multiple organisations and affected parties, coordinates emergency measures and supports local Municipalities. This covers technical coordination as well as support in getting financial aid for crisis management as well as recovery. The District Municipality was meanwhile equipped with a high-tech disaster management centre and highly qualified staff. With regard to water-related emergencies the Centre had and has to deal with flood prevention and (repeated) flood management during emergency, as well as drought management. During normal circumstances the District Municipality is involved in water related decision-making on low level only. Its key function is to act as bridging agent or boundary organisation during emergency. As, however both − flooding and the drought – have had serious impacts on citizens and local industries, public pressure on local authorities to proof that all possible measures for disaster prevention are implemented is very high. This will in detail be discussed in Chapter 3.7 which specifically addresses collaboration during the drought and under high public pressure.

The local Municipality – Knysna: The role of the Municipality in local water resources management and the way the Municipality operated and functioned in the local context seemed to be a key limiting factor for equitable and sustainable water resources management at the research site. The mandate of the local Municipality is formulated in section 152 of the Constitution of South Africa (Constitution of the Republic of South Africa, 1996) (Act no. 108 of 1996), which in relation to water covers the objective '*to ensure the provision of services to communities in a sustainable manner*' and '*to promote a safe and healthy environment*' (Republic of South Africa 1996: s 152). In Knysna the local Municipality acts as water service provider and the municipal key concept regarding local water resources management thus was to ensure access, short-, medium- and long-term water supply for the entire population.

The main challenges with regard to assuring sustainable water provision for the population – for now as well as for the future – was according to the municipalities' own concepts based on

- the lack of storage facilities
- the lack of resources (finances and technical staff) for proper operation and maintenance (O&M) of existing water supply and wastewater management facilities
- the lack of capacities for leak detection and loss reduction
- the lack of resources to adapt and increase the current water supply and wastewater systems to future and seasonal needs.

According to the municipal concept, high insecurities in planning and management of town water supply are mainly based on the lack of dams or other storage facilities, as water abstraction mainly comes 'from the river as it flows'. According to secondary literature, between 80 % and 100 % of the water use – depending on the location, comes from 'run-of-river schemes' (Department Water Affairs 2010a: 5, 2010b: 5, 2010c: 1, 2010d: 1). Municipal staff further stated that natural settings in terms of topography, shortness of the river catchments, cyclic water provision and cyclic seasonal needs would absolutely require construction of storage facilities to assure town water supply throughout the year.

The existing Municipal water supply schemes are described in detail in multiple Municipal reports. Based on these, stipulated needs for storage facilities, additional sources for water supply and different options for dams as storage facilities have been repeatedly investigated and documented in numerous Municipal reports over many years, as e.g. the Knysna Municipality Water Services Development Plan (Department Water Affairs and Forestry 2004a), the Knysna Bulk Water Supply Planning Study (Knysna Municipality 2007), the Comprehensive Integrated Water and Sanitation Business Plan for Greater Knysna (Knysna Municipality 2009a) and the Implementation Plan for Bulk Water Supply Augmentation for Greater Knysna 2009 – 2014 (Knysna Municipality 2009b), the Opportunity and Constraints Investigation (Knysna Municipality 2011). The current situation with regard to water service provision and related development plans are further outlined in municipal Water Service Development Plans, as part of Integrated Development Planning (see e.g. Knysna Municipality 2010, 2012c). However, decision-making and implementation lacked behind. The discussions and perceptions of core stakeholders around 'dams as storage facilities' to assure Municipal town water supply were emotional and controversial: whereas many stakeholders stated that the investigated options for dams were never followed up as the dams could just not be financed, other sources mentioned changing mindsets regarding the support of dam developments by the Department of Water and Sanitation or vested interests and local council politics as reasons for blocking implementation. Meanwhile the discussions on dams as storage facilities were further influenced by water supply infrastructure that had been installed under emergency regulation during the drought. Due to these additional – but malfunctioning – water supply measures, the discourse had further led away from investment into dams, as the Municipality would first need to justify, why the existing additional facilities, that were set up in cause of the drought were not fully operational and in use. This additional infrastructure covered implementation of boreholes, a pipeline for inter-basin transfer and a desalination plant in Sedgefield as well as boreholes and a Reverse Osmosis Plant in Knysna. Due to emergency needs and regulations, these infrastructure developments however were installed as emergency measures, thus with planning under high pressure and without conducting a prior Environmental Impact Assessment. The quick implementation caused technical and operational challenges, as it for instance lead to the wrong site selection for the desalination plant in Sedgefield, which was since then being blamed for having hardly been operational. Operational costs, especially for desalination, would also be relatively high, while the systems would now rather constitute 'expensive backup systems', of which it is unknown, if they would in case of another emergency really be functional. This is in further detail discussed in Chapter 3.7.

This situation during research seemed to be based on the lack of proper financing mechanisms as well as staffing of the local Municipality to sustainably operate and maintain the municipal infrastructure. A proper operation and maintenance scheme for water supply and sanitation infrastructure was not in place and could not be financed. Operation and maintenance would rather follow emergency management procedures: if serious infrastructure problems would arise, then funds would be allocated to fix the current problem only. This constituted a serious problem for sustainable operation of existing infrastructure, and will in short- to medium-term lead to further deterioration of the existing infrastructure and insecurities for town water supply.

A major obstacle for sustainable water supply planning and management by the local ('*B-*') as well as the District Municipality is the way, the Municipalities are financed: '*Project funding in general, and the availability of funding, both capital and operating, is viewed as the primary constraint for both district and B – Municipalities in order to achieve their developmental mandate.*' (Eden District Municipality 2013: 92). The water and sanitation business model from the 1990's, as basis for the Water Services Act, had not considered the high economic and population growth rates and increasing water demands as experienced by local Municipalities, combined with the imperative to provide water for all, whether they would be able to pay rates or not. Water and sanitation revenues are further paid into the General Income Account of local municipalities, but cannot be ring fenced to finance O&M of municipal water and sanitation infrastructure. The General Income Account is further used to fund all unfunded mandates of the local municipality. Estimations go as far as to state: *'The consequence(s) (…) have contributed to the deterioration of the water and sanitation business model, potentially to the point where it is no longer a financially viable asset for municipalities to manage directly unless there is a substantial redress in the funding allocated to housing, the unfunded mandate services or a legislated directive to have ring fenced budgets for water and sanitation from within its own funding sources.'* (Department of the Premier 2009: 7).

However, even if municipal income through water revenues would be ring-fenced, it was stated by different sources that the revenues could still not cover the actual costs, when considering the proportion of non-revenue water (NRW) versus revenue water. This shall be outlined in more detail: NRW is the difference between water supplied to a town's network and the billed quantity of water, as received by the customers. NRW covers three different components: physical water losses (real losses) due to leakages, apparent losses through illegal connections and inaccuracies in metering or data handling, as well as the third component of authorised but unbilled consumption, as e.g. for schools, hospitals. (Figure 10).

<table>
<tr><td rowspan="9">System Input Volume (corrected for known errors)</td><td rowspan="4">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and /or Distribution Mains</td></tr>
<tr><td>Leakages and Overflows at Utility Storage Tanks</td></tr>
<tr><td>Leakages on Service Connections up to point of Customer metering</td></tr>
</table>

Figure 10 The International Water Association's 'best practice' standard water balance (Lambert 2003: Figure 1)

McKenzie and Wegelin (2009) modified this table for the South African context by further dividing the component of 'revenue water' into three additional components:

- '*Free basic water – can be considered as billed and paid for at a zero tariff*
- *Recovered revenue water which is billed and paid for by consumers*
- *Non-recovered water which is reflected in the billing records as billed although there is no possibility of payment.*' (McKenzie and Wegelin 2009)

They also state that the last component would constitute a significant problem in many parts of South Africa, i.e. in typical low-income areas *(*McKenzie and Wegelin 2009: 170). In the research area, however, it was further confirmed, that under the current situation also a large part of the 'free basic' water provision, provided to previously disadvantaged communities, would not be metered, and thus would fall under the category of 'unbilled unmetered authorised consumption'. McKenzie et al. (2012: 22) also confirmed this as a general challenge in South Africa. Water losses, however without providing clear information how these figures are composed, were stated between 22 % to 28 % for Knysna and Sedgefield (Department Water Affairs 2010a: 5, 2010b: 5), at 48 % for the rural area of Rheenendal (Department Water Affairs 2010c: 3), and at 46 % for the rural area of Karatara (Department Water Affairs 2010d: 3), but accuracy of these figures must be questioned. Based on the lack of funding mechanisms for O&M, damaged and leaking infrastructure constituted a serious problem. However, the local municipality did neither have the resources for proper leak detection and repair programmes, nor had a great interest in installing further water meters to accurately quantify NRW. This was based on the fact that quantifying non-revenue water – but not necessarily increasing the revenue stream due to the outlined difficulties – would under the current Municipal model lead to bad internal audits.

Due to these complex challenges, not only in assessing, but also in defining non-revenue water in the local context, it could locally not be quantified how large the amount of NRW actually was. The outlined complexities however provide some insights into structural challenges in sustainably rendering water services to the people under the current funding model of the local Municipality as water service provider.

Sustainable town water supply further seemed to be challenged by the lack of funding mechanisms to properly plan and implement ***extensions*** to the water supply and wastewater system. Due to underfunding of local municipalities, as outlined above, decisions for water infrastructure extensions would not be based on integrated decision-making or holistic long-term planning, but would need to follow opportunities, to tap additional funding sources. During the drought, emergency funding was relatively easy to access and was used to upgrade local water supply infrastructure in a quick manner without proper planning, which however led to all sorts of sustainability-related challenges. This will in more detail also be elaborated in Chapter 3.7. Currently the local Municipality is investigating opportunities for implementing interbasin transfer between Knysna Municipality and the neighbouring Municipality (Bitou), as Regional Bulk Infrastructure Grants (RBIG) can now be accessed for these types of projects. Again, this route is rather followed due to the opportunity to tap additional funding sources, than based on investigations on the (local) suitability of this investment in the long-term perspective for the local Municipalities. As long as the way the local Municipality in its role as water service provider is financed is not revised, there seem to be little means to address and assure access, short-, medium- and long-term water supply in an equitable and sustainable manner for the local population.

South Africa National Parks (SANParks): The research site includes part of the Garden Route National Park (GRNP), which was proclaimed in 2009 and is managed by South Africa National Parks. SANParks is part of national government and reports to the Department of Environmental Affairs, but also acts as public entity. SANParks mandate and thus overarching concept on management objectives is based on the 'National Environmental Management: Protected Areas Act' (Republic of South Africa 2003): It is to '*protect, conserve, control and manage the national parks and other protected areas, including their biological diversity'* (Republic of South Africa 2003: chapter 1.3). Another organisational concept on management objectives was further formulated by SANParks in form of a vision: *'National Parks will be the pride and joy of all South Africans and the world'*, (South Africa National Parks 2006: 8, and SANParks annual reports until 2011). Since 2012 the vision and related organisational core concept has changed to '*South African National Parks connecting to society'* (South Africa National Parks 2012a: 1, 2013a: 1, 2014a: 1), thus putting a stronger emphasis on bridging between national parks and society. SANParks mission, reflecting both, concepts on management objectives and management principles is: '*To develop, manage and promote a system of national parks that represents the biodiversity and heritage assets by applying best practice, environmental justice, benefit sharing and sustainable use.'* (South Africa National Parks 2014a: 1). SANParks is further guided by a 'transformation mission' and concept: '*To ensure effective transformation both within SANParks and the broader society and economy, through the implementation of broad-based Black Economic Empowerment in support of the Constitution of South Africa.'* (South Africa National Parks 2006: 8). The above quotations reflect SANParks concepts on management principles and management objectives at the higher aggregated national organisational level. Of specific importance influencing and documenting SANParks concepts and settings at the local level is the GRNP Park Management Plan (South Africa National Parks 2012b)). In section 1.3 this document further outlines the legislative settings of particular importance for park management (South Africa National Parks 2012b: 5−6).

The Garden Route National Park consists of more than hundred partially disconnected and scattered sections that cover indigenous forest areas in the mountains as well as coastal areas. The 'Knysna National Lake Area' is further managed as 'Protected Environment', based on the '*Regulations for the Proper Administration of the Knysna Protected Environment'* (Republic of South Africa 2009). In recognition of the fragmented nature of national parks land and protected areas, SANParks sees a specific challenge and mandate in managing ecological corridors between these sections. These are reflected in identified 'priority natural areas'. The priority natural areas however cover different forms of landuse, such as forestry, agriculture and the towns of Knysna and Sedgefield, on state as well as private land. SANParks concept on their specific role and mandate at the Garden Route region is thus further documented as follows: '*SANParks seeks to achieve a conservation outcome in mountain-to-sea, coastal and east-west corridors that may impact on the environmental integrity of the GRNP. Functional landscapes where ecosystem functioning is enhanced or maintained and where opportunities for expansion of biodiversity are promoted are the drivers in our decision-making. In this context a 'conservation outcome' is defined as a state where conservation corridors in Priority National Areas of the GRNP are contributing to an expanded conservation estate to provide connectivity in the landscape, resilient ecosystems, improved river health and the protection of biodiversity and cultural / historic heritage.'* (South Africa National Parks 2010: 1). This reflects the driving concept of local

SANParks employees at the research site, with a strong emphasis on nature conservation.

With regard to local water resources management, SANParks is an actor that seemed to have rather indirect – but strong influence on water-related decision-making. The main water management challenges at the research site through a SANParks perspective were:

- Pollution of the Knysna estuary
- Management of the river mouth at Sedgefield / flood prevention and emergency management
- Infrastructure developments in Priority Natural Areas, specifically including the buffer zones of the rivers and below a 1:100 year flood line.

SANParks had influence on local water resources management through its role as commenting authority for development proposals and landuse change applications within the priority natural areas of the Garden Route National Park. Following its principal of ‘minimum interference with nature’, SANParks was in principal against all infrastructure developments in the buffer zones of the rivers and works on preventing such developments. This included a position against the construction of in-stream-dams as storage facilities for municipal drinking water supply, and thus was in conflict with the concept of the local Municipality, as explained above.

Another water related conflict in which SANParks was strongly involved played out in relation to SANParks management paradigm regarding the river mouth at Sedgefield and the discourse around flooding. Whereas flooding is a major concern in Sedgefield and a lot of action circles around flood management (especially revealing conflicts between flooded citizens and SANParks), it is a topic of less concern in the area of Knysna. This is related to the different topography, as well as other major ecological differences between the layout and functioning of the two estuaries. Whereas the Knysna estuary is classified as estuarine bay with a strong exchange of tidal water through a very narrow river mouth, the Sedgefield estuary is classified as temporarily open/closed estuary. However, a debate spins around a management approach that would keep the river mouth artificially and permanently open, in order to prevent flooding of the estuarine system (see e.g. South Africa National Parks 2014b: 21). Citizens had − under different political eras − been allowed to build their homes in the floodplain of this estuary and are since then repeatedly suffering from floods. The people living in the flood-plain are mainly economically relatively well-off white retired academics, and in principal very informed and vocal. Whereas they regarded it as the responsibility of the local authorities (District and local Municipalities) to protect them as well as the municipal assets from natural disasters, this was in conflict with the conservation-driven concept of SANParks. SANParks wants to interfere with the natural sedimentation and flooding process as little as possible, taking into account that people living in the flood plain have to live with and adapt to these events. The flooded citizens however, expect the District and local Municipality to fulfil their protective mandate and prevent flood events by keeping the river mouth artificially open and work against natural sedimentation processes.

The diverging concepts have led to strong conflicts between Municipalities (District and local), SANParks and the affected citizens who have grouped in numerous initiatives. It led to the establishment of a ‘Flood Action Group’, as well as all sorts of individually organized initiatives. Sedgefield did not offer many job opportunities, and its population was characterized on the one hand by a vocal group of (mostly white) retired academics and on the other hand by a large number of unemployed, less vocal ‘previously disadvantaged’ people. The retired academics had their own means and networks to conduct research projects on the dynamics of the estuary, ecology, flood risks, rainfall data, building up their own arguments on when and how the floods should be managed and prevented. However they did not seem to have properly established channels to discuss and influence local decision-making and partially clashed with local authorities and other citizens through their individual approaches. The intensive efforts did not lead to substantial changes in the management approach during the time of the research, but only to lengthy and technical discussions with other citizens at the Wilderness Lakes Catchment Management Forum. The real decisions about when and how the river mouth was opened were allegedly either made informally on a bilateral governmental level, or formally between the responsible governmental management bodies:

SANParks, the local municipality and the disaster management team of Eden District Municipality.

However, previously effective and timely opening of the river mouth was challenged by technical problems, communication problems between the authorities and the lack of an appropriate protocol between the responsible authorities. This has led to the total lack of trust of affected citizens into the effectiveness of local authorities in this regard. As this topic was of utmost importance for the citizens living in the flood plain and public pressure was very high, finally a protocol has recently been established, that stipulates the procedures for emergency breaching of the river mouth at Sedgefield in case of an expected flood event (South Africa National Parks 2013b), in order to improve effective collaboration in future.

SANParks' interactions as observed during field research mainly followed the paradigm of nature conservation 'at any means'. Other aspects of sustainability, such as social or economic concerns, seemed of less importance in local discourse and decision-making, but were supported in the context of their extended public works programmes, such as Working for Water, which aims at poverty alleviation, by eradicating alien vegetation to restore watersheds in a labour-intensive way. For this, national government provides extensive funding for state-actors to implement extended public works programmes. The opportunities and challenges of the Working for Water programme to effectively combine poverty alleviation with nature conservation are discussed in detail chapter 3.6.1.

The Catchment Management Forums: There were few formal ways of implementing integrated and holistic water resources management at local level at the research site. A Catchment Management Agency covering the research area was not in place during the time of the field research and also Water Users Associations did not exist. Water management challenges were discussed and addressed through two catchment management forums, as non statutory bodies in the hydro-organisational landscape: The Wilderness Lakes Catchment Management Forum and the Knysna Catchment Management Forum. These forums should by their constitution serve as a boundary organization or bridging agent for integrated water resources management (KCMF 2008: par

5, WLCMF 2007: par 5), but did neither have the practical means and legal power nor did they represent the diversity of stakeholders and actors in local water resources management to practically serve the purpose of a boundary organisation. However, the forums were the only local organisations that purely focused on local water resources management challenges, though with limited effectiveness for various reasons: Although initiated to play an active role to facilitate public participation for integrated water resources management on catchment level, the forums never got the required resources or legal power to actively play this role in local water resources management, but rather influenced discourse and decision-making through lobby work.

The forums consisted of a relatively homogenous group of mostly white citizens, covering some farmers, small-scale forestry, generally interested or affected individuals (retired teachers, engineers, et al.), some government representatives from Knysna Municipality, South Africa National Parks as well as the Department of Water and Sanitation. There were no participants from related sectors and industries, as medium- or large-scale forestry, golf courses and tourism, or the previously disadvantaged communities. In Sedgefield there was further no active participation of the farming community. The composition of the forum was formed by selected interested or affected parties that regularly gathered and discussed water related concerns but did not represent the diversity of stakeholders on the ground.

The discussions in the forum meetings circled around water supply, water abstraction, municipal technical challenges, pollution of the Knysna estuary and environmental concerns with regard to proposed new infrastructure developments. It did not discuss challenges for water resources management through an integrated equity or sustainability oriented perspective, as required by South African Water Policy.

However, the forums were identified as the only local bodies that provided the basis to be further developed to serve as bridging agent for an integrated water resources management approach, given that specific concepts and settings would receive further attention. Due to their (potential) role for local water resources management, research included the implementation of a participatory SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis with forum members in the context of two feed-back workshops at the end of the field research period. The results of the SWOT analyses can be summarised in highly concentrated manner as follows:

- **Strength:** High level of expertise, regular meetings
- **Strength / Weakness:** Mixed representativity of diverse stakeholders – representative enough? No inclusion of poorer community perspectives (is this wanted?)
- **Weakness:** No shared vision / little action
- **Opportunities:** Only local organisation that specifically addresses questions of water resources management
- **Threat:** No decision-making power / little action; No legal status; no / little financial resources; Unclear role in the future hydro-institutional landscape

In the following, also the detailed results of the SWOT analyses as originally formulated by the stakeholders shall be quoted, as these directly outline core stakeholders' concepts as well as settings that influenced the effectiveness of this local body for integrated water resources management. Whereas in Knysna the forum members preferred to conduct the SWOT analysis in a moderated plenary session (Table 9), the Wilderness-Lakes forum members preferred to develop the SWOT analyses through group work in two smaller groups (Table 10 and 11)[29]:

[29] For examples of SWOT analyses of CMF in KwaZulu Natal, South Africa see Karar (2000).

Table 9 SWOT analysis of the Knysna Catchment Management Forum: Summary of moderated plenary discussion

STRENGTHS (internal)	**WEAKNESSES (internal)** ***(cont)***

- *High level of expertise*
- *No statutory body, no resources (independence, little accountability, little responsibility, strength lies in discussion of water challenges and giving advice to authorities)*
- *'Advisory right'*
- *The forum is NOT a Water Users Association (a WUA would narrow the forum's focus down to the administration and allocation of freshwater resources – right now the focus of the forum and its respective advisory function covers a much broader range of topics; the number of water users in the area is quite small, although a WUA would have more power than a forum, the administrative effort for a WUA would not be justified)*
- *Commonality among members: a shared vision exists, which is the preservation of the lagoon and sustainability in water resources management*
	- *High level of expertise (difficulty to achieve compromise, debate follows debate)*
	- *No resources, no means to act, (this is both a 'Strength' as well as a 'Weakness') →range of influence is limited*
	- *'Advisory right' does not necessarily lead to action by authorities*
	- *Representation is not wide enough:*
	  o *community perspectives are currently not represented (physically and mentally) → entry route could be through stronger involvement of the different Ward councillors, however, they may not fully be representative for and trusted by their communities*
	  o *employed community members can't attend the forum, as it is taking place during working hours, unemployed community members can't afford to participate, as they can't pay for transportation and may further not be interested in attending without any payment.*

- *Forum acts largely on a local level, members know the situation on the ground very well* - *Authorities (Municipality, SANParks and DWA) are represented in the forum* - *Regular meetings* - *Mixed representativity of diverse stakeholders*	- *Little awareness of the forum's existence and activities by the broader public →Annual General Meeting (AGM) and other meetings should / could be announced to the public, improve public relations – if people have been informed about the forum's role, activities and engagement processes they have the choice to participate.* - *Forum has no focus on the topic of 'education'*
OPPORTUNITIES (external) - *Only organisation / forum that specifically addresses questions of water management – less of sustainable development* - *Catchments are small, rivers are short → the number of water user is very limited, which makes coordination and cooperation easier than in bigger river systems*	**THREATS (external)** - *No legal status; no / little financial resources* - *Unclear role of catchment forums in the future institutional landscape for Water Resources Management* - *Poverty, unemployment – focus of majority of people is 'to put bread on the table', not to conserve the lagoon – how to reflect this in the forum's activities?* - *Divided community – animosity, poor people feel 'left behind', no integration* - *Low level of education of general public*

Table 10 SWOT analysis of the Wilderness Lakes Catchment Management Forum: Documentation of group work – Group I

STRENGTHS (internal)	**WEAKNESSES (internal) *(cont)***

- *Variety of interested people that come to the forum meetings*
- *Expertise and talent*
- *Regular meetings*
	- *Limited involvement of governmental Departments (DWA, Department of Forestry)*
	- *Divided community*
	    o *Different interests and priorities*
	    o *Don't know statistics*
	- *Democratic make-up needs improvement*
	- *Ageism ('we are all old')*
	- *Limited time*
	- *Not integrating the expertise*
	- *Forum is not taken seriously by authorities (e.g. Municipality, SANParks)*
	- *SANParks is not attending (get them to participate meaningfully – work on public relations)*
	- *No legal status – or clout*
	- *Admin needs improvement (keep our meetings short and sharp, get a proper membership list for the forum, etc.)*
	- *Public relations need improvement – (making the forum more visible to the public, regular feed-back to public through local newspapers, such as the WildNews and Edge)*
	- *No action plan available (development of an action plan needed)*

OPPORTUNITIES (external)	**THREATS (external)**
- *Community is limited – manageable number* - *The forum is the only organisation that addresses integrated water management issues in the area*	- *Apathy by public – unless flood / drought* - *Limited / incorrect data – can't plan* - *Politics plays a role (disconnect with real problems)* - *No disaster management plan available* - *SANParks is ignoring the forum, (no attendance / possible arrogance)* - *Water Pollution*

Table 11 SWOT analysis of the Wilderness Lakes Catchment Management Forum: Documentation of group work – Group II

STRENGTHS (internal)	**WEAKNESSES (internal)** ***(cont)***

- *Availability of knowledgeable, enthusiastic residents / pensioners; We can leave a legacy to the society / to the next generation*
- *Many people have a long-term contact with the forum*
- *Meetings have a good representation of members*
- *The forum exists and has a long history*
- *Municipality and Department of Water Affairs do attend and do take interest of the doings of the forum*
- *We have quite a few secondary trained people*
- *We need to exist to pass on to the next generation*
	- *Lack of involvement of previously disadvantaged communities (→ develop mechanisms to increase previously disadvantaged involvement)*
	- *Forum is theoretically responsible for two estuary systems*
	- *Constitution needs serious revisions*
	- *Weak attendance of members*
	- *Doesn't have a real data base including:*
	  ○ *water laws*
	  ○ *plans of water systems*
	  ○ *minutes, agendas etc.*
	  ○ *Historic facts*
	- *The forum has only advisory function / has no leadership (→ improvement: forum should become a legal water advisory body or Water Users Association)*

	- *It is more a social gathering of people* - *Some people dominate the function of the forum*
OPPORTUNITIES (external) - *Water is GOLD to life and must be looked after* - *Emphasise implications of irreversible change caused by 'civilisation'* - *Encourage redesign of water tariffs* - *Change the Swartvlei into a freshwater lake* - *Start a fish farm*	**THREATS (external)** - *Lack of external leadership* - *Political interference* - *Amalgamation into regional bodies* - *Disinclination to compromise* - *In-flux of people (→ find ways of capping / limiting migration into area)* - *Rising cost of living* - *Apathy of population and authority* - *Lack of education* - *Hopelessness* - *No local government help* - *None use of potential* - *Our area storage (water storage) is a disgrace* - *Our wastage is unknown and not attended to (leaking pipes etc.)* - *Our cost of water is ill-logical* - *If the revolution takes place, the forum becomes useless (demographic representativity / participation of the masses could endanger the functioning of the forum)*

In the local setting, the CMF serve as core organisations that could facilitate holistic and integrated WRM at local Municipal level as bridging or boundary organisation. Nevertheless, this could only work in future, if resources would be made available to properly fulfil this role, if concepts and hindering settings as presented above would be reflected upon, addressed and shaped, and if the concept of 'representativity', as outlined in the forum's constitutions (KCMF 2008: par 6, WLCMF 2007: par 6), would receive greater attention. While in the meantime the research site has been included into the management area of the Breede-Gouritz CMA, holistic water resources planning and management is now under their responsibility, it is to be seen, if the means and resources of the CMA will be enough to facilitate integrated WRM not only on bigger catchment scale, but also in greater level of detail, as required and outlined for the study site. Here, facilitating and working with local organisations that already have a history and knowledge, as the local forums, seems the required solution to facilitate boundary work.

3.6 Exclusion: A Societal Phenomenon

This line of research has developed during field research based on the finding of almost systematic exclusion of so-called previously disadvantaged communities from local decision making. The experience of societal gaps, rather than boundaries, between the experts taking and implementing water and sustainability-related decisions and the majority of the economically poor, proofed to become of high importance when reflecting about obstacles for equitable and sustainable WRM. The Garden Route region is characterised by a long history of repression or 'fractured development', still leading to a situation where experts, managing or holding the power on water are mainly white, were the 'technical level' is white, while the majority of the user groups or recipients of services are coloured or black people.

Interviewees perceive the cultural divide at the research site as very sharp, and characterise this phenomenon as 'exclusion', 'unequal powers', 'fractured communities', 'racial divide' or 'segregation', to name only a few. The core concept of manifested segregation is also confirmed by secondary sources (Knysna Municipality 2012b: 48−49): '*Despite enormous strides in policy since 1994, Knysna Municipality still bears the mark of an apartheid society, with little integration evident. Integration is a reciprocal process that can only succeed in the long term if all members of a community accept their share of responsibility. Integration in KM is frustrated by many challenges, including:*

- *Historic patterns of spatial segregation planning, which continues to be reinforced by gated communities.*
- *Historic patterns of economic segregation due to apartheid and lack of job opportunities for the un-educated and poor*
- *Community development is aimed at addressing these challenges and these initiatives are therefore indispensable for the positive development and regeneration of KM.'*

Despite a strong, politically and morally driven discourse on public participation across the cultural diversity, decision making on the ground is still implemented and influenced by (mainly white) academics and governmental employees. Facing a practice of exclusion − however embedded in a strong political discourse on inclusion − constituted a societal paradox. This chapter examines modalities of exclusion of the previously disadvantaged communities in the context of equitable and sustainable local water resources management. The analysis reveals challenges for local 'boundary objects' to effectively bridge across the extreme societal dichotomy and inequalities. It further assesses concepts and settings for (the lack of) participation and collaboration of the previously disadvantaged communities in local decision-making processes. Understanding practices of exclusion and concepts and settings that foster the demarcation of boundaries between decision-makers and previously disadvantaged communities are considered to contribute to addressing and, in the long-term vision overcoming segregation in practical terms.

3.6.1 The practice of exclusion: Challenges for local boundary objects

This section covers an analysis of boundary objects in terms of organisations, programmes and processes that were specifically designed to assess and address the voices and needs of the previously disadvantaged communities. The boundary objects, in terms of bridging agents / organisations, processes and initiatives encountered at the study site showed different strengths and weaknesses and faced different challenges, which will be further outlined.

Boundary objects in terms of bridging agents, committees, forums or associations: The following core bodies were in place to serve as bridging agents between the poorer communities and decision-makers:

- **Ward committees and local Councillors:** The public perception by poorer communities of local Ward committees and Councillors as channel to communicate local needs between the poorer community and the Municipality was considered as not functioning properly due to a variety of reasons. First of all, people seemed to have little knowledge about the Ward structures and functioning of Ward committees and the role of Ward Councillors. The lack of functionality of Ward committees seemed to be based on two factors: Ward committee members should represent a specific local interest group, such as sports, soup kitchen or others, however, as further explained below, the local mentality in the townships is not characterised by grouping around specific topics of interest. There are very few, if no 'sports associations', 'soup kitchen associations' or similar. If people group, than rather around shared religion and beliefs, than shared interests, activities or initiatives. Thus, people get elected into the Ward committees as representatives for specific topics but do not have established channels to further communicate these topics between the local community, the councillor and the local Municipality. Further, despite the high official level of literacy, which according to Knysna's IDP is ranging between 80 % to 100 % for different cultural groups (Knysna Municipality 2012a: 18) this did not seem to reflect the local realities. The factual state of literacy, as communicated by community workers and as encountered during research, was rather low. Following the definition of the Department of Social Development, a literate person in the IDP is defined as someone '*aged 14 years and older (…) if they have successfully completed seven years of formal education*.' (Knysna Municipality 2012a: 18). However, local schools in the townships are facing enormous challenges to address and cope with the local realities of school kids. Thus, many school kids in the townships allegedly are formally passing school year after school year, without developing the expected skills, as class teachers cannot cope with keeping them in the same year for several years in a row. Thus, school kids can leave school with their formal degree, formally fulfilling the criteria for literacy and numeracy, but not having the associated skills. The lack of a proper functioning education system seemed to have provided a basis for the lack of participation of communities through local Ward committees or else, as sometimes even the committee members or Councillors may have low reading and writing skills. It was noted by community workers that the respective Councillors and committee members would consequently be embarrassed to call for public meetings, by fearing that participants may have better developed reading and writing skills. The partially low level of education of selected community representatives would thus cater for a lack of confidence to bridge between community and Council. However, the remuneration of Councillors would be an incentive to run for office, despite potentially not feeling confident to communicate between the municipality and the community.

- **Community Development Workers (CDW):** The Community Development Workers Programme (CDWP) was launched in November 2003, led by the Department of Public Service and Administration (DPSA), with the aim of Community Development Workers '*to work with government and other stakeholders in order to help bridge the gap between government and the community; and strengthen integration and coordination between services provided by government and access to these services by communities'* (Department Public Service and Administration 2010: 3). The job purpose of CDW is to *'liaise, co-ordinate, mobilise, inform and assist communities with access to services provided by government and to assist communities to identify and communicate their needs to government within the national, provincial and local government sphere in order to bring government closer to the people'* (Department Public Service and Administration 2010: 6). It is planned that one CDW should be employed per local Ward, however during the time of research only three CDWs were employed for ten Wards. The shortage of seven CDWs for Knysna municipality was in continuation of this situation also noted in the IDP for 2013/2014. (Knysna Municipality 2013: 167). In consequence, Knysna Municipality requested the Department of Local Government to assist in this regard, as funding was lacking. However, the acting director of the CDWP stated in January 2013 that *'Due to budget constraints no additional CDW's will be appointed at any municipality.'* (Knysna Municipality. 2013: 167). The tremendous shortfall of funding to facilitate the initiative to bridge the gap between government and community was considered as core setting hampering successful implementation of the programme. The CDWP also facilitates that local communities know their rights and also the established communication channels, to articulate their needs through the Ward committees. The CDWP has different well-prepared training materials in this regard (see e.g. Department Cooperative Governance and Traditional Affairs 2010a, 2010b), but due to extreme understaffing (three CDW for almost seventy thousand citizens) the programme cannot cope with all the needs, as partially the CDW need to be active on a personal level, as e.g. when supporting local citizens to obtain Identity Documents (ID).

- **Catchment management forums:** As outlined in Chapter 3.5.2, the catchment management forums, as non-statutory but important bodies for collaboration, were the local core organisations that should address water resources management in a holistic and integrated manner. In DWAFs guidelines for catchment forums (Department Water Affairs and Forestry 2001: para 2.2.4), it is stated that: *'A key area of focus is the need to ensure the involvement of previously disadvantaged groups in the entire process (of forum establishment).'* For both local forums, KCMF and WLCMF, the constitution states that: *'The Forum aims to have as wide a membership as possible from a demographic, geographic and interest point of view, thus ensuring representation of the communities, interest groups and local authorities in the Forum's area of jurisdiction.'* (KCMF 2008: par 6.1, WLCMF 2007: par 6.1). As outlined in Chapter 3.5.2, participants during the time of research did not include any representatives from previously disadvantaged communities. Whereas during 2004 and 2005, a few years after the start of the WLCMF forum, very few members from the previously disadvantaged community were attending the forum, they soon refrained from participating further, as they were under the impression that their presence was rather a matter of quota, than of true interest into their perspectives. Since then, no further interactions between the local forums and representatives from the poorer communities were noted.

- **Other forums, clubs, associations:** It seems to be part of a mostly 'white culture' to formally or informally gather in associations, clubs or organisations around a variety of different interests. This covers home owners associations, ratepayers and voters associations, sports clubs, wildlife and other conservation oriented associations. The numerous local initiatives that took notice and addressed water related concerns, were mainly driven by a conservation oriented, vocal group of white, mainly retired people (the 'greenies'), lacked representativity of other cultural groups, served to exchange and lobby across peers and did not function as bridging organisation across the societal divide. They further partially had well-established connections to lawyers, scientists, politicians, or other people that could effectively support developing and pushing conservation oriented local development, thus effectively hampering infrastructure development proposals. Despite the fact that the discourse of some of these associations was driven by inclusivity (as e.g. the 'Sedgefield Ratepayers and Voters Association', who specifically had amended their name by also including 'voters' and not only 'ratepayers'), the groups had originally been set up by white citizens, which still dominated the culture of these organisations during the time of research. The rather 'white' culture to associate through clubs, forums and associations, however, did not seem to be part of the cultures of previously disadvantaged communities. Previously disadvantaged community members were rather associating through an uncountable number of local churches, but not through associations pushing certain interests. The open involvement of local churches in political and societal matters at the research site could however not be noted. Local decision-making seemed to be highly shaped and influenced by well organised and very vocal mostly nature conservation oriented organisations. It was noted that local authorities − being obliged to demonstrate public participation and due to lack of other channels – mostly took the route to communicate local issues through these associations, like the Knysna Environmental Forum and the Sedgefield Ratepayers and Voters Association. The differences in local cultures, and the specific noted cultural feature of disadvantaged communities to NOT formally associate around specific interests, excluded them from the established local practice of decision-shaping, decision-making and public participation.

Boundary objects in terms of processes: Processes that focused on bridging the gap between communal needs, decision-making and governmental support included intensive public participation programmes implemented by the local Municipality in the context of Integrated Development Planning (IDP). This was further completed by strong efforts of the district Municipality to mediate between needs and support on a strategic district level. Further, during the time of research, the DWA facilitated public participation processes to communicate the contents of the National Water Resources Strategy II and to collect feed-back by stakeholders. Depending on the setting of the processes or workshops, the level and quality of participation was experienced very differently:

- **IDP on district level:** Public participation at district level was experienced in a one-day IDP summit or feed-back workshop, proofing a relatively high cultural representativity. A variety of diverging concepts on water management, community needs and sustainable development challenges were framed and addressed in an integrated manner for the (higher aggregated) district level. This tool was not specifically designed to assess needs of specific local communities on grass-root level, but to rather assess strategic challenges on district level to achieve development mandates.
- **IDP on local Municipal level:** Integrated Development Planning at Municipal and Ward level reflected a highly intensive programme of consultation with the public, according to Wards. However, as described above, the Ward structures did not function very well in the townships. Whereas Ward committees of wealthier areas rather addressed needs such as paving of roads or walkways or renaming of streets, Ward committees of poorer areas articulate basic needs in terms of housing,

schools or a police station or the need for job creation. The attitudes during consultation processes with the poorer communities were experienced differently, partially characterised by silence of participants, partially by a confronting attitude. The local Municipality provided intensive efforts, but was challenged by a lack of trust. However, the local Municipality was highly motivated and intensively investing in this instrument for bridging the societal gap. Documentation of the processes remains highly impressive (See Knysna Municipality 2012a: 41−51, 2013: 53−108).

- **DWA and the NWRS II:** DWA conducted two workshops in the research area to share and discuss the National Water Resources Strategy II with local stakeholders. Whereas also the district Municipality, in line with their mandate, had facilitated stakeholder consultation at a strategic level through their IDP summit, the approach of DWA was inherently different. Instead of facilitating one summit or workshop to address all political and local levels at once, DWA specifically designed two workshops at two distinct societal and political levels: one workshop, implemented at the Eden District Municipality, addressed local authorities and decision-makers, and a second workshop explicitly addressed members from previously disadvantaged communities. This second workshop was conducted at Thembalethu, the main township of George. Both workshops were totally differed in outline, atmosphere, discussion style and also regarding the input provided by stakeholders. Whereas the workshop at the district Municipality was characterised by long presentations and rather moderate to no discussions, the workshop in the township was marked by short presentations, active participation and rather a confrontational attitude by community members. Discussions covered questions on lack of access, lack of water for subsistence agriculture, lack of knowledge and rights and procedures to engage. A total clash of concepts regarding the workshop objective became obvious in this second workshop: DWA wanting to share and discuss a national strategy with end-users from the townships and local people wanting to share and discuss individual and communal concerns related to water. Settings of DWA required the discussion of the Strategy with the public, and DWA did so through intensive efforts. However, the workshop design proofed a conceptual gap between the National Department and the end-users. This was an example for the extraordinarily high emphasis on public participation given by National Government – and the real-life challenges in designing and 'doing it the right way'. One reason leading to the principal misunderstanding on the meaning and objective of the workshop was assigned to the lack of proper translations. Whereas DWA was fully convinced that the workshop in the township would be conducted in English language, the Department had respectively outlined the whole programme in English. This created a first and important 'clash of concepts and cultures'. Participants took this as offence, and enforced the whole meeting to be conducted purely in Afrikaans and Xhosa. Translations between Afrikaans and Xhosa were facilitated by DWA representatives on the spot, however, since then partially own government officials from DWA could not further follow the workshop, as some of them did neither speak Afrikaans nor Xhosa. It would have improved the exchange to either design a single workshop to address all political and societal levels at once (authorities as well as community members), as successfully done through Eden District Municipality in their IDP summit, or – if purely addressing the local communities – to respectively design the local workshop differently, for instance through involvement of the CDWP in workshop design and preparation, as well as a straight facilitation of the workshop in the local main languages of communities, which are Xhosa ort Afrikaans, and with equal translations into the other language as well as English.

Boundary objects in terms of mechanisms – Working for Water (WfW)[30]: One of the core programmes, which aim to bridge between concepts of poverty alleviation and nature conservation, is 'Working for Water'. In this study WfW is

[30] Due to the importance of the Working for Water programme or mechanism in the local as well as international (research) context, as well as its explicit aim to combine poverty alleviation with conservation benefits, which was actually experienced as major 'clash of concept' in the research area, this boundary object will be analysed in greater detail.

categorised as boundary object in terms of a programme as well as in terms of a large scale mechanism for poverty alleviation and nature conservation. 'Working for Water' (WfW) has been established in 1995, with the aim of '*sustainably controlling invasive alien species by 2020 in order to contribute to economic empowerment, social equity and ecological integrity*' (Turpie et al. 2008: 791, following Department of Water Affairs and Forestry 2004b). Removal of alien species does not only support the restoration of hydrological functioning of river catchments and improvement of surface water run-off, but also restores natural fire regimes and the productive potential of biodiversity and land (Turpie et al 2012: 788, van Wilgen et al. 2008). This is done in South Africa in a labour-intensive way, to support the overarching goal of poverty alleviation by creating short- to medium-term jobs for unskilled workers (Coetzer and Louw 2012). There exists an ample range of literature on this internationally recognised programme, with regard to the background of the programme, its reasons and modes of implementation, its worldwide uniqueness with regard to its dimension and the challenges and related learning processes for implementation (see e.g. McConnachie et al. 2013, Rodricks 2010, Turpie et al. 2008, van Wilgen and Richardson 2012, van Wilgen et al. 1998, 2008, 2011a, b, 2012a, b, Woodworth, 2007). It was stated that control costs over fifteen years amounted to 3.2 billion South African Rands (or US$ 457 million) (van Wilgen et al. 2012a: 29), with the bulk of funding provided through poverty relief programmes (Turpie et al. 2008: 791).

Despite acknowledging the significance of the project, it's effectiveness has however repeatedly been questioned, both, with regard to its conservation and restoration objectives (see e.g. van Wilgen 2009: 340, van Wilgen et al. 2011b, van Wilgen et al. 2012a), as well as with regard to its social benefits (see e.g. Buch and Dixon 2009, McConnachie et al. 2013). An extensive range of highly specialised research focuses on aspects of conservation ecology (van Wilgen at al. 2011b: 285−287), tackling detailed questions such as '*hydrological effects of invasions, economic impacts of invasions, prioritization studies, water use by invasive alien plants, the economics of clearing operations, the inclusion of control considerations for alien plants in water-resource planning, biological control, remote sensing for mapping the extent of invasions, genetic techniques to improve understanding of invasions and their management, ef-*

fects of control and rehabilitation projects, effects of invasive eucalypts on riparian areas, emerging invaders' (van Wilgen at al. 2011b: 286). This is implemented by well-known South African research organisations, such as the Council for Scientific and Industrial Research (CSIR), the Water Research Commission (WRC), the Agricultural Research Council, the Department of Science and Technology – National Research Foundation's Centre of Excellence for Invasion Biology and the South African National Biodiversity Institute (SANBI) (van Wilgen et al. 2011b: 286). At SANBI, a specific research unit funded by WfW as part of SANBIs Invasive Species Programme (SANBI ISP) focuses on research on new invasions and improvement of institutional coordination to effectively implement national eradication plans, with an annual budget of 36 million South African Rand (in 2013 equivalent to approximately three million Euro) (Wilson et al. 2013). However, topics such as the social impacts and effectiveness of the programme to alleviate poverty, as the main argument for national government to provide funding, are totally under-researched, and there exists hardly any information on this. At the opposite, current literature factually states, that it was required to shape the discourse around poverty alleviation, in order to assure national funding: '*Although studies had shown that the programme would have had significant benefits even if job creation had been very small, the programme's ability to create many jobs, and therefore directly affect the lives of many people, was fundamental to securing funding and sustaining political support. Linking the programme to job creation, and aligning it with the new government' s Reconstruction and Development Programme, provided the novel strategy that made the package eminently saleable.'* (van Wilgen 2011b: 387). This goes in line with Turpie et al. (2008: 1−2), stating that *'Conservation in South Africa has historically been perceived as a luxury and the concern of the wealthy, especially since almost all conservation efforts are focused on the protected areas, which tend to be geographic, economic, and socio-political enclaves. Conservation therefore enjoys a low priority in relation to other more pressing social issues on the political agenda. There is pressure to utilise land and water resources as opportunities for economic development, sometimes in direct conflict with conservation goals. This has serious implications for the future health of terrestrial and aquatic ecosystems and their capacity to deliver goods and services that also* *contribute to social and economic welfare. Recognising this, there has been considerable effort to describe biodiversity values and the socio-economic impacts of ecosystem degradation (e.g. Turpie 2003; Turpie et al. 2003). This may justify conservation efforts, but does not guarantee an improvement in the allocation of scarce government resources to conservation in South Africa.'*

In general, only very few recent studies could be found that analyse effects by WfW or other expanded public works programmes (EPWP) on the poor or (just) on implementation challenges that are impacting on effectiveness through a societal perspective (see e.g. Buch and Dixon 2009, Coetzer and Louw 2012, Hough and Prozesky 2012, 2013, McConnachie et al. 2013, Mtapuri 2014, Urgenson et al. 2013). It further seems, that research efforts on social impacts, despite poverty alleviation being the main driver for assurance of national funding, are almost non-existent, whereas, as outlined, considerable efforts, funding and institutional structures address conservation driven research. This again reflects an exclusive and excluding practice, this time manifesting societal gaps through scientific research priorities and practice, diverting the aim of a boundary object that had deliberately been developed to address societal needs to manifest conservation concepts. The desperate situation with regard to (lacking) research on societal impacts can be summarised, as done in McConnachie et al. (2013: abstract): '*Recent studies have raised questions over the effectiveness of this program in achieving both its restoration and poverty alleviation goals. This is the first study that we are aware of that synthesizes the knowledge of managers on both the poverty alleviation and environmental outcomes of a public works project.'*

Social impacts are expected through different means by the creation of income, capacity development and training, development of entrepreneurial skills, and specifically addressing gender and other imbalances by ensuring employment quota (60 % women, 20 % youth and 2 % disabled) (Magadlela and Mdzeke 2004, Buch and Dixon 2009). Each of these elements contains inherent own challenges for effectiveness and sustainable impacts and Buch and Dixon (2009: 1, abstract) argue that '*while WfW has produced some positive tangible social development outcomes, these are neither substantial nor sustainable.*' Assessing or quantifying these in detail is impossible under the current way of project monitoring, which will be discussed through the realities as encountered at the study site.

Concepts and discourse around WfW as encountered at the study site, were almost purely circling around ‘nature conservation’, ‘restoration of river catchments’, ‘increasing water yields’, ‘a mechanism for PES’, and almost non-existent focusing on the originally intended impacts on poverty alleviation. Neither poorer communities in the research area nor conservation focused organisations were aware of the range of local WfW activities, partially due to the activities mainly being implemented in mountainous areas, thus out of sight. Awareness was strongly dependant on the level of exposure to concrete activities nearby. In the research area, two actors were implementing WfW activities during the time of the research, both with totally different approaches, funding schemes and mechanisms. Eden District Municipality was implementing activities at comparatively small scale, mainly on private land, and struggled with stable funding, which allegedly led to breaks for local contractors and challenged societal effectiveness. The main actor of considerable importance was SANParks, with a steadily increasing budget from 3.7 million Rand in 2009 to 6.68 million Rand in 2012. SANParks cleared alien vegetation in protected areas, as well as buffer zones, mainly focusing on the Garden Route National Park, but also just starting to get involved in private conservancies. During the time of research SANParks project managers worked with approximately twelve out of seventeen local contractors, selected through tendering procedures, and clearance happened in a strategic manner in the order of prioritised areas.[31] The focus on clearance from ‘source to sink’, thus during the time of the research focusing on mountainous areas, also explained the reduced level of awareness on WfW, as WfW activities were not easily visible. However, some local contractors – and related communities, such as the local Rastafarian community, proofed both, profound knowledge on the importance for conservation of water sheds, as well as practical knowledge and skills to work as contractor. SANParks just started to initiate a research pro-

[31] Figures were abstracted from interviews as well as Minutes of Meetings of the KCMF and WLCMF. However, data was difficult to assess, and figures may not be precise, but the presented data gives an idea of the general range, as well as the way of monitoring.

ject, assessing social impacts of their WfW interventions on local families, especially on the effects of women being away from their families. The prescriptive quota to employ 60 % women, combined with SANParks efforts to clear in remote areas, required women to be away from home for one to two weeks. However, results of this study were yet outstanding. So far, reporting on societal benefits only covered inputs in terms of person days, and did not allow insights into and impacts on communities (be it intended or unintended). SANParks expenditure budget for 2011/2012 was 10 200 000 Rand (South Africa National Parks 2012: 105). SANParks reported that in 2012 15 355 man-days were provided at the Garden Route area, with initial clearance of 2543 ha, and follow up clearance of 3174 ha (Wilderness Lakes Catchment Management Forum 2012). This way of reporting is in line with SANParks annual reporting at national level, were social deliverables through extended public works programmes are presented purely in terms of inputs in the categories of: number of people employed, person days worked, training days, SMMEs created, SMMEs used, amount paid to SMMEs (R million) and total expenditures (see e.g. South Africa National Parks 2007: 54 and all annual reports of the following years). However, local monitoring of WfW, neither of Eden District Municipality, nor of SANParks, went beyond monitoring of inputs instead of impacts. This is in fact a noted methodological challenge, confirmed by McConnachie et al. (2013: 548), who quote that the '*overriding focus of expanded public works programmes (EPWP) (is) on measuring person day inputs and the quantity of beneficiaries*', and that '*goals are often framed as inputs (e.g. money spent, people employed) rather than outputs (reduction in the extent of invasion, or progress toward a societal goal within a defined timeframe'.* Thus with this current model of data assessment and monitoring, it is impossible, to assess **impacts** of WfW on poverty alleviation, and thus to streamline its effectiveness in this regard. They further argue that despite the repeated identified need but noted shortfalls in proper monitoring of socio-economic impacts of WfW, this has since not been changed and is further challenged by the lack of proper baseline data. It has further been recommend that the *'programme moves towards outcomes-based monitoring, and not just the monitoring of inputs or activities. This would be in line with a movement* *towards results-based monitoring and evaluation, in order to manage for results.'* (Coetzer and Louw 2012: 799).

In summary of the above, Buch and Dixon (2009: 138) shall be quoted: '*The focus of WfW undoubtedly remains on the conservation of water and biodiversity, and in its present form social development would appear to be only a peripheral goal, attainable through temporary job provision and its associated economic multipliers. A key challenge for the future, therefore, is to integrate social development more fully with the programme's environmental goals. Although this echoes the many criticisms levelled at the community based conservation approaches of the past, where the mere inclusion of people in such initiatives was regarded as a proxy for poverty reduction, empowerment and social development, the context of WfW is rather different. The participation of people in WfW's conservation activities is fundamentally essential; without the active eradication of alien invasive species South Africa's biodiversity and water resources will be degraded.*' This also summarises the potential that the mechanism as boundary object has to bridge between the experienced and still prevailing societal gap, expressed through a 'clash of concepts' between 'conservationists' and 'previously disadvantaged communities', who need to focus on the fulfilment of the basic needs. However, getting this boundary object to properly function in this regard requires a shift of research activities away from the dominating focus on conservation ecology, to societal impacts and effectiveness in poverty alleviation. Assessing and monitoring societal impacts requires a shift away from 'input monitoring' as discussed above, towards a model of outcome or result-based monitoring. There exists extensive experience in this regard, developed in transdisciplinary manner and adapted to developmental contexts, e.g. through South Africa's own experiences with regard to Strategic Adaptive Management, as applied through SANParks, or by international development organisations.[32] This requires a detailed development of impact models, a proper baseline assessment followed by simple and practical impact monitoring mechanisms. It is only through these efforts, that

---

[32] For instruments for practical and decentralised monitoring and evaluation (M&E), that could improve WfWs effectiveness, see e.g. <www.giz.de/en/aboutgiz/517.html>, viewed 28 May 2015, further especially outlining results-based monitoring systems.

WfW could become an effective boundary object, to support sustainable upliftment of previously disadvantaged communities.

3.6.2 Drivers of exclusion: Concepts and settings

Trying to analyse conceptual phenomena and settings that characterise the previously disadvantaged communities and that constitute obstacles for fruitful collaboration across the societal gap between decision-makers and excluded water users was challenged by the enormous cultural diversity and richness that was found within the townships. This covers – following classical South African categorisation – not only different groups clustered according to their skin colours or race (classically distinguished between Black, Coloured, White, Asian and others) and respective differentiation of concepts, but an extreme additional diversity of cultural groups also within these clusters. Acknowledging this diversity, South Africa has eleven national languages, three of which are dominant in the research area (Xhosa, Afrikaans and English), and communicating across multiple languages already constitutes a barrier in itself. In order to understand, how the gap between the decision-making minority and the ‘unheard and invisible’, culturally extremely heterogeneous majority is constituted, concepts and settings of citizens from the townships were analysed with their relation to integrated water resources management, equity and sustainability. Following approaches from grounded theory, it was tried to transcend abstraction with regard to explaining the phenomenon of exclusion. Due to the high complexity and richness of local cultures, beliefs, diverging economic situations, educational backgrounds of people living in the same spatial sub-area of a township, it was however of utmost difficulty to derive separable clusters of mindsets that allowed insights into reasons for this extreme societal gap, but an attempt is provided below.

Access – a matter of housing: To redress failures of apartheid in terms of excluding citizens from access to resources based on their race or skin colour, one core principle of the National Water Act is ‘equity’. This principle shall assure equal access to water, as well as the benefits derived from water for all South Africans. Access to water in ‘developed’ areas is easy, as all houses have house connections and different types of access to sanitation. Water supply for developed areas was specifically challenged during the drought. However, access for these areas is not considered a general problem, and water consumption is high. Access to water and sanitation in the townships – thus for the great majority of the population − primarily seemed to depend on the type of housing people were living in, rather than on general water availability or scarcity. Housing types and related access seemed to depend on historical developments of townships, amended through different eras of governmental housing projects, now further influenced by recent municipal spatial planning, and generally based on 'land planning and politics'. Acknowledging the difficulties in providing precise figures, as also stated in Knysna's IDP (Knysna Municipality 2013: 125), available figures will be included, where they help to visualise grounded findings and dimension of contrasts. The water use in the Municipality '*varies between 320 l/person/day for full water and water-borne sewer service on large properties to 6 l/person/day for settlements, where no formal water supply exists.*' (Department Water Affairs and Forestry 2007: 21). Considering concerns on accuracy of available data, access to water and sanitation is as follows (Figure 11 and Table 12): 67 % of the population are estimated to have house connections, 13 % have yard connections, 14 % have access to public stand posts within two hundred meters walking distance, and 16 % have access to public stand posts within a walking distance of more than two hundred meters:

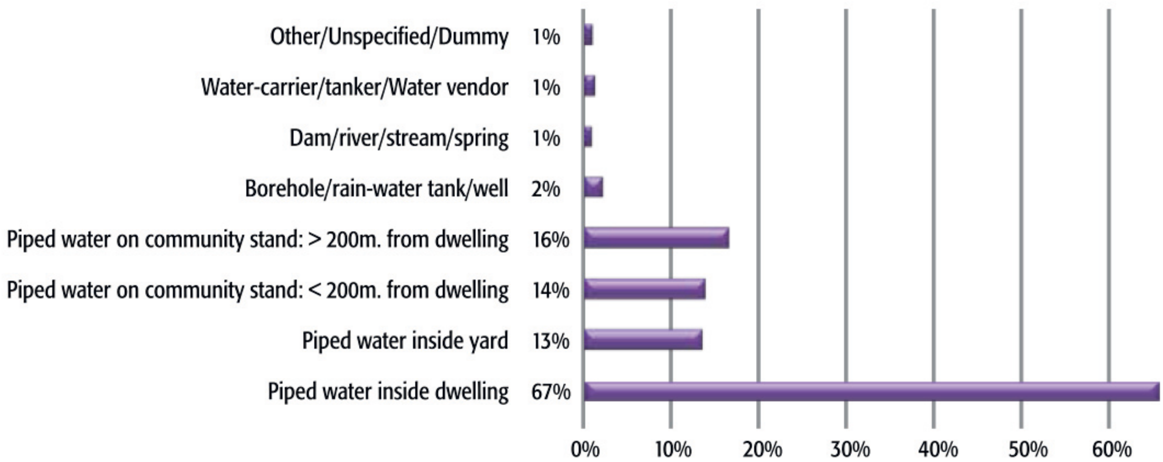


Figure 11 Water provision infrastructure (Knysna Municipality 2013: 45, following Stats SA 2011)

Table 12 Sanitation coverage (Knysna Municipality 2013: 46)

Description	2010/11	2011/12
	Actual	Actual
Household		
Sanitation/sewerage: (above minimum level)		
Flush toilet (connected to sewerage)	13 977	14 687
Flush toilet (with septic tank)	2 466	2 466
Chemical toilet	0	0
Pit toilet (ventilated)	0	0
Other toilet provisions (above minimum service level)	0	0
Minimum Service Level and Above Sub-total	**16 443**	**17 147**
Minimum Service Level and Above Percentage	**94.4**	**94.4**
Sanitation/sewerage: (below minimum level)		
Bucket toilet	0	0
Other toilet provisions (below minimum service level)	0	0
No toilet provisions	973	4 303
Below Minimum Service Level Sub-total	**973**	**4 303**
Below Minimum Service Level Percentage	**5.6**	**5.6**
Total number of households	**17 416**	**21 893**

However, the situation as encountered in reality, both for Sedgefield and Knysna, seemed a lot more fuzzy and complicated. Access to water and sanitation within the township seemed generally very chaotic, as different standards for access to water and sanitation had been applied under different political eras and housing schemes: some areas had historically grown and others were recently designed and newly developed. Whereas some houses had a metered yard connection and people regularly paid for their water, they did not necessarily have access to a toilet. Others – living in recently built subsidized houses – had house connections and flush toilets, no water meters, but suffered from other water related problems. Some houses in the steep hills get regularly flash flooded during heavy rains based on the wrong site selection for construction and amplified by malfunctioning storm-water drainage systems.

Other prefabricated subsidised houses show considerable problems of moisture and mould due to alleged poor construction quality. No municipal budget exists for O&M of these houses, and people have generally little means to repair occurring damages by themselves. Table 13 illustrates the struggles, when trying to categorise the complex range of housing types or types of dwellings.

Table 13 Dwellings: Example for categorisation (Knysna Municipality 2013: 38)

Type of Dwelling	2001	2011
House or brick structure on a separate stand or yard	9 244	14 295
Traditional dwelling/hut/structure made of traditional materials	870	139
Flat in a block of flats	262	616
Town/cluster/semi-detached house (simplex, duplex or triplex)	366	819
House/flat/room, in backyard	236	340
Informal dwelling/shack in backyard	338	1 266
Informal dwelling/shack, squatter settlement	3 241	4 000
Room/flatlet not in backyard but on a shared property	99	89
Caravan or tent	48	34

Based on both – type of dwelling and further legal or illegal initiatives of individuals or groups to gather access to water and sanitation by own means if not provided by the local Municipality − concepts within the townships respectively varied from ‘we have no water problem’ to a variety of different, major water problems. These cover:

- No access to water due to a housing backlog – the biggest articulated need is housing and the related access to services in terms of roads, water and electricity
- Water pollution (algae in the drinking water, brown colour of drinking water, ‘running tummies’ of children)
- Water shortages (either by broken pipes or technical pressure problems)
- Overflowing septic tanks – no O&M by the Municipality

- Flooding of houses (wrong site selection, no proper stormwater drainage),
- No water for subsistence gardening

To simplify, based on own observations and data, townships − regarding the access to water and sanitation − could be clustered as follows:

Some areas were characterized by individual type one or two-storey housing on separate plots and surrounded by little open space. This could refer to historically grown areas (former areas of the coloured population), or also to newly developed subsidized housing areas, and apparently access to water and sanitation in both housing schemes constituted a minor problem.

A second cluster comprised plots with a solid housing structure and several (poorer) attached shacks to it on the same plot. The solid houses were constructed under different political eras, mostly equipped with a water connection (either with a tap within the house, or on the plot) and access to sanitation (mostly either with flush toilets or septic tanks). The (informally constructed) shacks or rooms attached to the house, partially very poor and basic, were rented out and tenants usually shared water connection and sanitation with the owner. However, water and sanitation systems were partially malfunctioning, septic tanks overflowing, and the local Municipality had no maintenance budget for these houses and systems. Local people complained about poor construction quality of houses and related infrastructure and about the local Municipality as 'not caring', while at the same time the affected citizens would neither have the means nor the knowledge to repair broken infrastructure by themselves.

A third settlement cluster in the context of water supply and sanitation were the fully informal areas – spread around the townships, and mostly covering wooden shacks. In these areas numerous households shared public taps and limited public toilet facilities within different walking distances. Partially people had constructed their own toilets of various systems near the house, due to security concerns and inconveniences to use public toilets. This was mostly done by digging a hole in the ground and erecting a small wooden structure above. If the toilet was 'full', it either got emptied by the people, or else – if space was available – it got covered with earth, a hole was excavated a meter aside, the toilet shack was moved, and this functioned until the 'new' toilet was filled up again. These attempts of self-help, due to security concerns (attacks and rapes) were not considered as 'safe and equitable access to sanitation' and further led to health problems and contamination of groundwater resources. These informal areas were partially not included in the municipal planning due to different reasons, such as land not belonging to the municipality or not featuring basic standards for construction, due to steep slopes or other reasons. Thus there were also no attempts by the local Municipality to develop these areas, before legal and technical matters would be resolved, which is being addressed through the municipal IDP.

Production and reproduction of societal gaps − design principles for town water supply: The biggest articulated and tangible need and a topic of utmost emotional and political relevance was housing development and all the services that are associated to this (roads, electricity, water and sanitation, a postal address, thus also easier location of the property by police or ambulance, in case of emergency). The community noted that the Municipality would not be able to provide housing and infrastructure in adequate number, quality and time, further complained about the total lack of transparency with regard to processing of housing applications and numerous, highly emotional stories of 'messed up applications' were told. This utmost emotional topic and the way that people feel it would be addressed by the government seemed to have created a total lack of trust in the government structures and thus no basis for willingness to cooperate.

Access to housing is dependent on many factors, such as availability of municipal land, funding, capacities to implement housing schemes and many more. One setting that seems to foster the production and reproduction of the societal dichotomy and inequalities seems to be manifested in the Guidelines for Human Settlement Planning and Design (Department Housing and CSIR 2000). The guidelines state, that '*The establishment of economically, physically, environmentally and socially integrated and sustainable built environments is one of the most important factors which will contribute to harnessing the full development potential of South Africa and addressing distortions of the past and* *the future needs of our growing population.'* (Department Housing and CSIR 2000: i)

In different talks it came out, that disproportions with regard to water supply in the townships compared to other parts of the town were manifested through the Human Settlement Handbook (Department Housing and CSIR 2000). The handbook amongst other topics provides construction standards for water supply and bases these on estimated water demand and 'historical water consumption' patterns of water users. Thus, the guidelines are manifesting advantages for water users that historically already had prioritised access to water and are reproducing disadvantages for those, who never had proper access to the natural resource (see Department Housing and CSIR 2000: Chapter 9: 20). Thus the guidelines are working against the principle of 'equity'. Design criteria for water supply systems are provided in the handbook in a double standard: different technical parameters, such as pipe diameters or residual pressures, apply for 'developing areas' and for 'developed areas' (Department Housing and CSIR 2000: Chapter 9: Design Criteria: 19−24). Thus a dual system for access to water is defined and manifested through the Handbook, and thus not seen as fully redressing the disproportions of access to water resources, as implemented under apartheid.

Access – also a question of power: Whereas access to services especially in informal areas is principally bad, exemptions can be observed. Understanding reasons, why some people are 'better off' despite the same (lack of) rights to be connected to municipal services, gives insights into societal structures of self-help. Some examples of different scales shall be highlighted:

- **Backup through the church:** At Knysna, one of the sites being under spatial dispute is an area that has been blocked for formal housing developments, as it is belonging to the South African National Roads Agency (SANRAL) and shall eventually serve for the relocation of the National Road N2 that currently leads through town. It was unclear, if this plan will ever materialise and meanwhile other options seemed to be more appropriate. Studies and discussions were going on for a long time and people having settled in this area had meanwhile set up impressive structures, but without protected rights or access to services. Structures included pre-school, churches, private housing including partially well-maintained privately set-up water and sanitation facilities. One plot was particularly well developed for the community, based on an initiative of one of the South African Christian churches. This included a pre-school, water provision from the public tap and topped up by rainwater tanks. Sanitation was assured through 'rent-a-toilet' – systems: portable toilets were bought from a private provider from the neighbouring Municipality of George, 60 km away, who also regularly came to empty and maintain the toilets. Whereas the church had the means and interest to develop the place to support the local community and to maintain the place and pay for privately organised services, the Municipality did not support any development of access to Municipal services in this area, as the land officially not belonged to them. However, also the Municipal attitude seemed to have changed back and forth, access to electricity was confirmed and should have been granted, and was also paid for at the Municipality, but the installation never materialised. The Ward committee could not effectively bridge between the church and the Municipality, although the Municipality had raised this as the proper route to apply in this case. However, despite the strong difficulties as encountered based on land politics among governmental departments (SANRAL and the local Municipality), access to water, sanitation and other services could be developed for the community through external support from a church.

- **Communal self-help – Judah's square:** Another example of self-help was given through the local Rastafarian community: here, a religious group had gathered and created a space for themselves, bridging across all races and embracing coloured, black and white people. The housing schemes were self-constructed and well-maintained, the houses had access to water and sanitation, and maintenance of water infrastructure was to some extend done by the community. The area included communal facilities, a church, a pre-school, a bed & breakfast, a small arts and crafts shop and a small kiosk. Here, access could be developed through self-help of a religious community without back-up from the mother-church. The Rastafarians were further almost the only local community with relatively well-established marketing[33]. It seemed that any local authority or conservation-oriented initiative (e.g. SANParks, the Garden Route Initiative, the Working for Water programme or the River Health Programme) that seeked to collaborate with local communities, had approached Judah's Square, as they were relatively well organised and easy to approach. However, Judah's square seemed to constitute a demarcated and small 'local phenomenon', that made it relatively easy for external organisations to associate and engage with, but engagement seemed to remain a closed-loop phenomenon and little benefits spread to other communities within the township.

- **Individual self-help – the Rainbow Community Project[34]:** Whereas in the examples above the power to overcome disadvantages was financially and spiritually backed up by a religious community – either with support from a mother-church – or by self-organisation, also limited initiatives of individual up-raising could be found. The Rainbow Community Project is one of these examples: this project, implemented on grass-rot level, was fully based on individual means and spirit of a local woman. It focused on early-childhood development, supported the development of pre-schools, facilitated procurement of school-uniforms and school-equipment for the very poor and organised community gatherings and cultural events. This was financed by private means and fund-raising through tourists, by facilitating township tours, providing local catering services and multiple other jobs. The family developing the project shared the vision of a 'rainbow-community', not segregating people in mind or heart based on racial or different social or cultural backgrounds. They aimed to become fully self-sufficient, in terms of water (rainwater), sanitation (ecological sanitation systems) and electricity (solar). Land

[33] <www.judahsquare.co.za/>, viewed 28 May 2015.

[34] <www.knysnalivinglocal.co.za/>, and <www.knysnalivinglocal.co.za/community-experiences/dining-experiences/34-sister-food.html>, http://rainbowprojectknysna.yolasite.com>, viewed 26 May 2015.

that was previously not considerable for development, due to steep slopes, had been levelled with construction machines at private costs and a house including a communal hall was developing steady but slowly. The project revealed a lot of real-life struggles when trying to uplift the community against economic and political and societal odds across the societal dichotomy – and also within the township. A long struggle went on with the local municipality to legalise the initiative and the related development, to rezone the land that had been made suitable for development by own means, but decisions had allegedly been blocked by Ward and municipal council politics. At the time of the research, the matters were not yet resolved. Structural settings considerably hampering the development of the project related to the lack of access to knowledge and information on rights and means to engage, lack of access to funds, difficulties to create an own income based on tourism, and difficulties to effectively engage with local government structures, based on Ward and Council politics and official red tape.

Settings of powerlessness – the case for the majority: Whereas the above cluster revealed structures of power to develop access to services against all odds, based on external support from a mother-church, through associating within a religious community or based on an individual strong spirit of upraising, the majority of previously disadvantaged communities however seemed to be speech- and helpless.

Powerlessness to uprise or participate can be explained through concepts and settings of the previously disadvantaged communities. The challenges that the majority of citizens in the townships are facing are tremendous and cover a very broad range of social and economic problems, which in total seemed to make it almost impossible for the economically poor, to leave the settings in which they were born and to get a chance to meaningfully improve their living conditions or participate in any local debate. The concepts and settings of considerable influence, hampering upraising and public participation, have been identified as the following (acknowledging questionable data quality, figures illuminating the situation are provided in Annex 9):

- **Poverty, unemployment and dealing with financial debts:** High poverty (absolute and relative) and high unemployment rates constitute serious obstacles for improvement of local living conditions. Community members further stated that dealing with personal financial debts constituted a serious problem and created harsh dependencies of citizens from local money lenders.
- **HIV / AIDS and tuberculosis:** Major health related challenges, through HIV / AIDS as well as tuberculosis (TB), added to the social struggles and meaningful participation. The IDP addresses this topic as follows: *'A comprehensive HIV / Aids Strategy needs to be developed to address challenges of the evolving epidemic of HIV / AIDS and tuberculosis in the Greater Knysna Municipal Area. This Strategy will be regarded as Council's commitment and determination to face HIV / AIDS and TB not only as medical and health problems, but also to address them as cultural, social and economic issues which affect all sectors of our society and every family in our community.*' (Knysna Municipality 2013: 140)
- **Crime and drug abuse:** High crime rates, rapes or attacks, reflected the lack of personal security and hampered participation, as private houses always needed to be guarded by an adult. Substance or drug abuse constituted a serious social problem in the townships. The topic also affected numerous children: '*Sexual offences reported to the police increased with an alarming 67 % between 2011 and 2012 while drug related crimes also show a considerable increase*' (Knysna Municipality 2013: 42).
- **Malnutrition:** A limited number of local soup kitchens works on improving the nutritional situation of school children, as a large number of children are not getting one proper meal per day.
- **A failing education system:** the education system did not seem to address and be able to cope with the local realities of school kids in the townships. Kids were facing numerous challenges, starting from unsafe environments at home and the surrounding townships, where it had been reported that kids had been disappearing, further ranging from malnutrition, poor health care, up to 'simple' obstacles, such as lack of school equipment or transportation. The lack of a proper education sys-

tem was perceived as one of the strongest settings hampering socio-economic change and meaningful participation.

Clash of concepts: In total, basic needs of the majority of the previously disadvantaged communities did not seem to be met in one or more of the categories above. This created a serious obstacle for respectful living as well as meaningful participation, as the main concerns were 'to bring bred to the table' and to 'create a safe space for the family'. The concept of 'assuring the basic needs' locally clashes with other concepts of verbally active organisations of different scale and power, such as SANParks, CapeNature, the Knysna Environmental Forum (KEF), the Wildlife and Environment Society of South Africa (WESSA), the Garden Route Initiative (GRI), strongly fostering the locally dominant concept of nature conservation. Despite a partially strong discourse of these organisations on inclusion of concepts of conservation and community development, practical success could not be confirmed at larger scale. Clash of concepts especially referred to the sectors that did or should influence the local economy and cater for jobs. Whereas emphasis in the public discourse was strongly on tourism as main economic driver (supported by a conservation driven concept, also including preservation of local water resources and the conservation of pristine rivers and the Knysna estuary), the concepts of the communities however reflected that tourism could not provide stable job opportunities for the majority of the poor and that it was further very difficult for them – despite numerous trainings offered by Knysna Municipality − to meaningfully profit from tourism, be it indirectly or through direct engagement with tourists. The previously disadvantaged communities at Knysna Municipality rather saw their skills in other sectors than tourism (especially in construction), but job opportunities in the construction sector were very limited, constraint by the lack of land for development projects, and limited capacities to provide Municipal services within the urban edge in general. In case construction projects got implemented, the 'fight for jobs' was very strong and political, and people were highly emotional about the process how workers got selected to participate, and which racial group or Ward they would represent, so that the benefits of job creation would be evenly distributed across the local community.

According to the Spatial Development Framework (Knysna Municipality 2008), the agricultural sector, forestry and industry had been identified as providing the most stable opportunities for employment, whereas it stated that '*a more comprehensive tourism offering has also been noted as being important.'* (Knysna Municipality 2008: 24). The potential of tourism was further analysed in Knysna Municipality (2012b), however, recommendations remain vague. Despite the importance that was previously assigned to agriculture and forestry for job creation, these sectors are declining. Primary data analyses revealed that the major loss of forestry-related jobs was assigned to the translocation of Knysna's sawmill that was operated on Thesen Island, to George, which is about 60 km away. This had led to a great loss of jobs as well as sources for municipal income through industrial rates and taxes, and Knysna Municipality had lost their only large industry. Since then, Knysna Municipality itself is considered to locally be the largest employer. Thesen Island was then developed, starting in 1998, as high-class residential and holiday island, which however did not equally provide stable job opportunities for the local community. The development of Thesen Island supported a symptomatic change of the local discourse leading away from Knysna as a 'historical timber town', providing jobs through forestry and timber production, to Knysna as 'traditional tourism place'.[35] By substituting the local sawmill through high-class housing and holiday facilities, and by respectively supporting that people with (high) economic resources and respective power would buy properties at Thesen Island, the local discourse had been strengthened with regard to 'tourism as main economic driver', and nature and estuary conservation as 'goose that lays the golden egg'. The developments and investments that had led to a 'tourism based' discourse, away from job creation through industry and / or forestry seemed to have meanwhile created an irreversible paradox that challenged equal and sustainable development of the local Municipality.

Agriculture in the area was characterized by dairy production and vegetable farming, further lifestyle and hobby farms, and the total absence of emerging farmers or farmers from previously disadvantaged communities. Despite the

---

[35] On the self-concept see: <www.thesenislands.co.za/index.html>, viewed 26 May 2015.

potential that had been assigned to agriculture for job creation, the absence of emerging farmers was argued to be based on high land prices, a slow pace of land reform and other factors. Also here inherent contradictions of concepts and settings fostering the production and reproduction of societal gaps became evident:

- The stipulated need for extension of the agricultural sector to provide stable job opportunities versus the noted decline of the agricultural sector and an absence of emerging farmers;
- A dominant discourse around tourism and nature conservation, high land prices and a growing number of 'hobby farms' versus the acknowledge seasonality of the tourism sector and the limited opportunities for stable job creation through tourism for members of previously disadvantaged communities.

Whereas the conservation-driven discourse circled around concepts as Payment for Ecosystem Services (PES), the challenges for these approaches to practically function across the extreme inequalities and for the high numbers of poor as reflected through the Gini-coefficient were not schematised. Due to the importance of this specific finding on clash of concepts for local sustainability, one longer quote from an interview shall be provided, illuminating the limitations of conservation to cater for job creation in this context of extreme inequality. Although referring to Kruger National Park, it symptomatically reflects a similar clash of concepts as encountered at the Garden Route, though at the research site encountered at considerably smaller scale:

'*(What communities want is) jobs, without even hesitating, there are loads of projects and literature that has shown that if you ask anybody what is it that they want, what do they want to benefit from a protected area, it's not resources like everybody thinks, it's jobs. And the problem is that this perception is never really going to change, because of how economy has changed. People's dependency on things, converting from livelihoods and subsistence livelihoods to a cash economy, has changed quite a lot. And the things that people value within their household are much more cash based, so people need money. So the problem is that we have for instance two million people next to the Kruger National Park and if you just look at Kruger, they can employ about 2*

000 people. So even if they double the amount of people working in Kruger, it's 4 000 people and there's still two million people that want jobs. People almost perceive a national park as a solution to world poverty or to national poverty or regional poverty and the big issues that need to be dealt with are these mismatched perceptions of what can come from protected areas and then appreciation or an understanding of what the intangible benefits are, that come from protected areas, like clean water.' (Interview in 2011).

Challenges for collaboration: As mentioned, the majority of the previously disadvantaged communities were not visible in local processes of engagement, despite a strong emphasis that local government and organisations were putting on public participation across the societal gap. Concepts and settings that challenged effective public participation were analysed as the following:

- **Lack of knowledge and information on rights, structures and instruments to engage:** As outlined before, the general level of knowledge on rights and channels to engage was very low, and resources to address this noted shortfall, as e.g. through the CDWP were very limited.
- **Lack of trust, skills and confidence:** Especially the relationship to government was clearly characterised by frustration and lack of trust and the main concept was 'they do not care'. This expanded to the lack of trust in other local organisations and forums that invited to meetings, workshops or processes of engagement. Meaningful participation was further hampered by the lack of confidence and means to engage with perceived 'authorities', as well as within the local community.
- **'No rates – no rights':** A strong concept shared across the community was assigned to 'as we pay no rates, we are not granted any rights'. Whereas the local communities felt that no rights were assigned to them with regard to access or operation and maintenance of infrastructure by the local Municipality, as they would not be paying rates and taxes, they further felt that areas in town were people paid rates and property taxes would get served better and quicker. The Municipal concept was contrary: Municipal employees rather commented, that people from the local communities would not report, if something was broken; as soon as the

Municipality would receive a complaint they would have regulations on how to follow up on the complaints, and they would stick to these regulations and treat every citizen the same. Thus, although the legal system assigned rights in terms of provision of services to all South Africans, previously disadvantaged communities felt neglected by government, or dealt with without priority, due to paying no or lower rates for municipal services. Ratepayers' positions towards a concept of cross-subsidy were divided, partially fully acknowledging the need for an economic share of responsibilities based on different financial means to contribute and partially not supporting that cross-subsidy would be an inherent part of facilitating 'equity'. For the second group of ratepayers the concept of 'equity' meant that 'everybody should pay the same rates for accessing (the same) municipal services'. The reasons for not paying rates in the townships however were wide and complex, challenged by structural problems as outlined above. As mentioned before, subsidised housing during the time of research came without water meters, as this was not a priority of Government for different reasons – but in contrary some houses in the townships had water meters from previous eras and paid for their services. It further needs to be distinguished between people that based on the lack of income had no ability to pay rates and taxes, and people, that were also encountered during research, that would actually like to pay for their services and have the financial means to pay, but did not encounter proper channels to do so. Not all people living in the township were necessarily extremely poor, but the individual economic situation was neither reflected in nor related to having legal access to municipal services: People with stable income did not necessarily live in a proper house with related access to municipal services or had a title deed for the land they were living on. Due to the lack of land, people had to settle were they found a safe space, and this led to situations, where people with stable income were living in a shack as back dwellers somewhere, not paying rates, as they had no metered connections.

- **Lack of positive examples:** Apart from not knowing how to engage, talks had revealed that communities had partially never even thought about engaging as means to facilitate any sort of change. The local mentality was strongly driven by a culture of resignation and helplessness. Practices and politics of the two major parties, ANC and DA – changing power back and forth in Knysna's Municipality − seem to have not only created the total lack of trust into any political party, it further supported the development of a feeling of '*they are all anyhow the same'*. Neither elections nor communication per se through any official structures were perceived as means for change. This may partially be assigned to the history of powerlessness and suppression of rights and participation during apartheid, and aggravated by big disappointments into the African National Congress (ANC) after the end of apartheid.

- **Fragmentation within the townships:** It was found that people who grouped in communities seemed to develop a certain power to be able to jointly improve their living conditions, and self-organise access to services. It was thus further questioned during research, why other citizens in the township would not do so. This was assigned to the following: also communities within the township were societally considerably fractured, what hampered collaboration and uprising. The distinction of societal groups within the townships based on races and cultures was very dominant in language, discourse and self-perception.[36] For the coloured people a relatively homogenous concept did emerge, that related to them as the 'silent', 'moderate', 'invisible' and 'forgotten' ones, following concepts of: '*the Whites had everything during apartheid, the Blacks have the ANC and 'toitoi' (organise strikes and marshes, in case of need) and we have nothing*.' Another strong and shared concept allegedly hampering collaboration of the coloured population within their own culture was the strong self-perception of '*We don't stand together*'. They however conceptually perceived this to be different for the black and white population, whom they perceived to group to achieve their interests. As outlined, the 'white population' indeed followed a culture of as-

[36] This, interestingly, was the only boundary concept in terms of terminology that was shared across different races and cultures: the distinction of citizens based on their race / skin colour, and the respective separation into 'black African', 'Coloured', White', 'Indian/Asian' and 'other' people.

> sociating and grouping, however 'black' population did not seem to have a shared concept in this regard. They further did neither all participate in marshes and strikes (as perceived by the public) nor all followed the ANC, but were rather further fractured into different groups. However, these complex and complicated cultural and societal structures reflect the extreme cultural richness and diversity of the South African population, which may challenge collaboration, but is an intrinsic asset of South Africa.

As outlined, the challenges for the local communities are broad and complex, and achieving meaningful participation requires many challenges to be addressed at various levels. This is done through various programmes, but always challenged by the scarcity of resources to work on all the identified needs, as well as the extreme inequalities, that constitute the major challenge for equal and sustainable development.

3.7 Emergency: Collaboration under Pressure

Data analysis revealed that collaboration of stakeholders under water-induced emergency, as experienced during the drought was inherently different from water resources management under 'normal' circumstances, as described in Chapters 3.5 and 3.6. Decision-making during the drought had wide-ranging impacts for the future of equal and sustainable water resources management at the research site and shall therefore be discussed in further detail. The emergency situation had triggered that finally decisions were taken, funding mobilised and measures implemented that had been pending over several years prior to the drought. It seems that water stress and emergency improved collaboration across stakeholders and over different governmental spheres, supported the development of shared concepts and eased settings for collaboration. Data analysis revealed that patterns of collaboration during and after the drought considerably deviated from patterns of collaboration during and after flood events. This can be explained by the different nature of the emergencies: the drought was a 'slow onset disaster' and in its severity affecting the region for the first time. It had socio-economic impacts on numerous sectors, affected the entire population and lasted more than two years.

This allowed the slow development of shared concepts and mechanisms of collaboration over time. The floods, repeatedly affecting the research area and rather characterised as 'rapid onset disasters', had also caused the development of mechanisms for collaboration, though not of equally wide ranging intensity, effectiveness and consequences. The concepts and means of collaboration under flood emergency differed from mechanisms under drought conditions, probably as they did not develop over a longer lasting period, as experienced during the drought. Flood mitigation during emergency rather triggered 'once-off reactions' in terms of mitigation measures and recovery. However, as outlined in Chapter 3.5.2 especially the affected citizens – as a consequence of repeated flood events – strongly, but with limited effectiveness, engage to opt for effective mitigation in future. During the drought the processes of collaboration over different governmental spheres were shaped over two years and were leading to substantial outcomes with considerable impact on sustainable and equitable water resources management in the research area. This study thus focuses on the analysis of drought related mechanisms of collaboration, in the light of the development of shared boundary concepts, eased settings and the development of boundary objects – as tools that facilitate collaboration and joint decision-making. However, especially during the first months of the drought, processes of collaboration and decision-making were rather chaotic and unstructured, overlapped, or were hampered. An attempt to derive abstracted phenomena and structural patterns that shaped mechanisms of collaboration is given below.

3.7.1 The drought (2008/09 – 2011): Background

As outlined before, the research area is characterised by relatively short river catchments, and town water supply for the two towns of Sedgefield and Knysna is mainly based on 'run-off river schemes'. Sedgefield depends almost entirely on river flow of the Karatara River, Knysna is to about 80 % dependent from 'run-off river abstraction'. Water in Knysna is mainly coming from the Knysna River, and to a small portion (~25 %) topped up by the Gouna River. Prior to the drought, both towns were facing challenges to assure town water supply during the peak holiday season in December and January, which coincides with the driest time of the year. Water restrictions were already in place prior to the drought, as precautionary measure and due to limited capacities of the Wastewater Treatment Plant, which though had meanwhile been upgraded. During the peak holiday period, the population considerably increases and the dimension of this situation was estimated as follows: the population of Knysna consists of approximately forty-four thousand, and a holiday population of about fifteen thousand people (Department Water Affairs 2010a: 4), Sedgefield is estimated to have approximately thirteen thousand fife hundred citizens and a holiday population of fife thousand visitors (Department Water Affairs 2010b: 4). The rural area of Rheenendal has an estimated population of three thousand four hundred people (Department of Water Affairs 2010c: 3) and the rural area of Karatara of approximately seven hundred people (Department of Water Affairs 2010d: 3). Water stress during the peak season is assigned to the increased number of people aggravated by higher water consumption patterns of visitors.

Already during December 2008, the local Municipality (LM) Knysna had noted the low rainfall, but was faced with high water consumption patterns. Therefore, demand reduction measures in terms of public awareness campaigns and compliance monitoring of water restrictions were initiated. However, in January 2009, the town of Sedgefield faced a situation where the Karatara River, the source of town water supply for Sedgefield, stopped flowing. For Sedgefield, being almost entirely dependent on river flow, the situation was out of sudden very dramatic and immediate measures had to be implemented within few days to provide the town with water. The reasons for the sudden and severe situation of water scarcity were identified as the meteorological conditions, thus a very dry summer season, combined with the high water demand during the peak season, general absence of water storage facilities, and − due to the low water level of the Karatara river − a backflow of saline water up to the abstraction point, which made the abstracted water not suitable for human consumption. The local Municipality Knysna urgently searched help from the Eden District Municipality and immediate support measures were jointly implemented.

This covered the costly exercise of trucking water from the neighbouring municipality to Sedgefield, filling it into a reservoir that could feed into the normal reticulation network. Within about a week, an alternative water source was found and an emergency pipeline was laid between the neighbouring Hoogekral River that was still flowing, and the Karatara River. Further, nine boreholes were drilled to top up town water supply by groundwater resources. As a result, expensive water trucking could be terminated. Within the same time frame, a consulting company identified different short-, medium- and long-term measures to address the local situation, as it was not clear, how long the drought would last. Further, the Environmental Health section of EDM was asked to implement public awareness campaigns, covering health related aspects of safe water handling as well as awareness measures to reduce water consumption.

A few weeks later also in Knysna the situation became very tense, as also the Knysna river had a highly reduced water flow. The availability of limited storage facilities for town water supply however gave Knysna a little bit more time to assess and implement solutions to top up town water supply and water did not need to be trucked in by tankers. For both towns a detailed emergency intervention programme was designed, that lined out various options for immediate (within days up to two months), short-term (within six months), medium-term (within twelve months) and long-term measures and respective funding required (Knysna Municipality 2009a, b). These reports served as boundary objects, thus as medium to communicate the Municipal needs to core stakeholders at district, provincial and national government level to commonly assess opportunities for funding and procedures for quick implementation.

Funding was secured through a mixture of sources (Table 14 and 15), which led to a variety of medium to long-term measures to be implemented. Funding sources included reallocation of outstanding payments for Municipal flood recovery from the years 2006 and 2007 to current drought disaster mitigation, funding through the Municipal Infrastructure Grant (MIG), own funding from the local Municipality and financial support from National Treasury. Measures covered groundwater abstraction through boreholes (twenty eight drilled and seventeen equipped, producing an estimated yield of 3 Ml / day), the implementation of a mobile desalination plant in Sedgefield (completed during December 2010, with a contracted capacity of 1,5 Ml / day), as well as a Reverses Osmosis Plant (RO) in Knysna (completed during August 2011, with a contracted capacity of 2 Ml / day). The implementation of these measures, especially the installation of the two desalination plants, have wide-ranging effects on the future of the local Municipality's town water supply, as both plants have been blamed for never having been fully operational. This will be explained in greater detail below.

Table 14 Summary of funding allocations for drought emergency assistance 2009 – 2010 (adapted from Holloway et al. 2012: 39)

Municipality	Funds in South African Rand		
	Urban Infrastructure	Agricultural relief	Total
Knysna	57 862 072	1 023 615	58 885 687

Table 15 Summary of funding allocations for urban water supply infrastructure 2009 – 2010, by funding source (adapted from Holloway et al. 2012: 39)

Municipality	Funds in South African Rand					
	National Treasury	Municipal Budgets	Municipal Infrastructure Grant (MIG)	Regional Bulk Infrastructure Grant (RBIG)	Eden DM	Total
Knysna	40 100 000	8 350 000	9 212 072	0	200 000	57 862 072

3.7.2 Concepts, objects and settings under pressure

Data analysis revealed that the complex processes of collaboration during the drought were overlapping at various governmental levels and in time. They were amended over the period of two-three years, and changed in line with changing concepts and settings. The drought conditions were first noted in Knysna Municipality, but expanded during the following year also to the neighbouring Municipalities of George, Mossel Bay and Bitou and also to the neighbouring district Central Karoo. It was the local Municipality Knysna, together with EDM who considerably pressured and facilitated the development of mechanisms for collaboration across governmental spheres and Departments, as they were the first to be confronted with a severe shortage for town water supply. Further, the region was not considered to be prone to droughts and no monitoring or emergency plans for drought mitigation were in place. The disaster hit the area totally unprepared and mechanisms for collaboration and mitigation had to be developed under pressure and from scratch. Establishing effective mechanisms took about ten months. This coincided with the period that in the wider temporal and spatial picture of the drought, extending over different municipalities and over a period of more than two years, was retrospectively defined as ‘risk escalation phase’ (see Table 16). Other Municipalities later profited from the established communication channels that had been initialised by Knysna Municipality and EDM and that had developed during the first 10 months of the drought, by quicker achieving disaster declarations and related support.

Table 16 Phases of the 2008 – 2011 Southern Cape drought (adapted from Holloway et al. 2012: 35)

Phase	Dates	Classification	Description
I	2008: January–December	Risk accumulation	Declining annual rainfall, combined with increasing water demand. 12 month Standardised Precipitation Index (SPI) – Moderate
II	2009: January–October	Risk escalation	Poor rainfall, declining dam levels. Sedgefield’s water source depleted (January 2009) 12 month SPI (January–December 2009) Severe – Extreme

Phase	Dates	Classification	Description
III	November 2009–April 2010	Risk intensification	Poor rainfall. Nov 2009: Disaster declaration: Eden District Emergency measures DWA domestic water restrictions introduced in Hessequa, George, Knysna, Mossel Bay and Bitou Local Municipalities (January 2010)
IV	2010: May–December	Risk stabilization	Demand measures institutionalized DWA domestic water restrictions reinforced, George, Knysna, Mossel Bay and Bitou (July 2010) DWA domestic water restrictions reinforced, George, Knysna, Mossel Bay and Bitou (December 2010) Rainfall restored. 12 month SPI (January 2010–December 2010) Mild
V	2011: January –June	Risk de-escalation	Substantial rainfall in many areas. Favourable dam levels maintained. DWA domestic and industrial use water restrictions for Hessequa, George, Knysna, Mossel Bay and Bitou lifted (April, 2011) Water demand monitored.

The complex dynamics of collaboration, as well as the implications for future town water supply for Knysna Municipality will be described in the following, by discussing initial difficulties and dynamics of collaboration, the breakthrough for 'formalised' collaboration, the role of DWAF during emergency management as custodian of South Africa's water resources and the implemented measures and consequences for equity and sustainability. This will be done through the view of the boundary work framework by analysing the development of shared boundary concepts of the problem definition and management objectives, the shaping of settings, and the use of boundary objects for collaboration.

Initial dynamics of collaboration: Collaboration between the local and district level was established very quickly, and a shared concept of the urgency of the local situation was immediately visible within few days. The shared boundary concept was: *'there is no water, we must provide water to the people'* and respectively action was taken and water was supplied, but collaboration with the provincial and national level was not yet very effective. The concept of emergency during the following months slowly 'trickled up' from the local and district level to the Provincial level, pushed by selected interventions and by worsening drought conditions. Finally, in August 2009, thus eight months after the occurrence of the emergency in Sedgefield, stakeholders across all governmental spheres started to collaborate, and regular mechanisms for communication were established, also based on the strong support of the Head of the Provincial Department of Local Government. The dynamics of this process of developing a shared concept, tools for collaboration and the shaping of settings for collaboration shall be described in further detail:

During January 2009 it was communicated by the local Municipality to the district Municipality that the Karatara river, Sedgefield's source of town water supply, had stopped flowing, leaving the town with two days of water supply. Immediate water supply measures were undertaken and, at end of January 2009 the Council of Knysna Municipality had decided to request the declaration of a local disaster in line with the Disaster Management Act (Act 57 of 2002). However, seeking assistance from Provincial and National Government, including the Department of Water Affairs and Forestry (DWAF) in the situation of emergency did initially not work as desired and it became visible that the settings in terms of roles and responsibilities, options, processes and protocols to seek support during a drought were not clear to the core stakeholders over different governmental spheres. Especially DWAFs role and effectiveness was perceived controversially by the stakeholders and again (see Chapter 3.5.2) regarded as 'rather reactive – never proactive', in some cases creating more confusion than providing effective support, which will partially be illuminated below. In principal, the farer away the officials were from the actual local emergency situation (geographically as well as administratively), the less they seemed to share the concept of immediate and emergency need. Knysna Municipality had thus formally asked the Eden District Municipality on February 3rd to follow up on the request of a local disaster declaration.

A disaster declaration serves a 'boundary object' between core stakeholders for emergency management: it articulates and manifests a shared concept of need across multiple governmental spheres and it serves to ease settings for collaboration by pooling additional resources and clarifying roles and responsibilities for disaster management. In addition, financial resources can easier be accessed, additional staff can be assigned to mitigate the problem, bureaucracy can be reduced and legal requirements for license applications and related procedures can be eased under emergency. In general, a disaster declaration suddenly fosters a shared understanding of a problem, and support can be facilitated in an easier way.

The required process to declare a local disaster starts at the local Municipality, who submits − based on a council resolution − a request for disaster declaration to the district level. The District council decides whether or not to pass the request on to the Provincial level. The Provincial level decides through a cabinet resolution, whether or not to support the request. If the request gets supported, it is passed on to the National level. The National Disaster Management Centre assesses in a classification process, if they can confirm the local disaster. If so, this needs to be published through a Provincial gazette. As soon as the local request has successfully passed the process, additional resources can be assigned by different governmental spheres. In line with this procedure, the Eden District Municipality had per Council resolution approved the request from Knysna Municipality and had passed it on to Provincial Government during April, three months after occurrence of the water shortage. The delay in this process was explained by a 'hung district council', and as explained, a district council resolution was required to continue the procedure to officially declare a disaster.

Whereas the local Municipality and EDM in cooperation with a local consulting company were immediately busy with identification of concrete mitigation measures, the Provincial Premiers Coordinating Forum had decided at end of February to investigate the local situation through a task team and to analyse background and reasons for the sudden severity of the situation and assess required actions to mitigate the disaster through a broader perspective. End of April 2009, a detailed report by the task team was submitted to the Premier of the Provincial Government of the Western Cape, outlining the crisis situation in Knysna, giving reasons for its sudden severity and providing clear recommendations how to mitigate the crisis (Department of the Premier 2009). This report was considered as providing unbiased evidence and information on the current situation, and seemed to have been a first effective 'boundary object', bridging between the urgent local needs and the Provincial Government. It further paved the road for the later development of a shared concept of need and emergency. The Provincial Disaster Management Centre (PDMC), in consequence of the report, was now also politically backed up to approach National Government to investigate options for funding of mitigation measures. Formally however, little else was happening after the request of Eden District Municipality to declare a local disaster and finally, in a meeting at the PDMC 8th of July, held between core stakeholders including the local Municipality, it was decided and communicated that the request for disaster declaration would at this stage not be followed up further by the Provincial Government.

In consequence of three factors: a) the decision of Provincial Cabinet not to follow up on the local disaster declaration at that stage, combined with b) worsening conditions of drought throughout the entire Eden District and c) an increasing pressure by the local Municipality seeking support from Provincial and National Government, the PDMC on August 26th initiated a first broad stakeholder workshop, the 'Eden Water Crisis Meeting'. This workshop included representatives from meanwhile also other affected local Municipalities, Eden District Municipality, Provincial Government and National Government and served to assess the current situation, identify key actions and develop support for the implementation of these actions. The first Eden Water Crisis Meeting overlapped with the official letter of the PDMC to EDM, from August

27 2009, stating that Provincial Cabinet did not support the disaster declaration at this point of time, but would assess measures to assist the local and district municipality otherwise.

One of the main challenges when bringing together core stakeholders from different governmental spheres for the first time at the Eden Water Crisis Meeting was the noted lack of a shared concept across stakeholders of what constitutes a 'drought'. In fact, there exist more than hundred fifty definitions of this term, and the definitions can be classified in line with four categories: meteorological, hydrological, agricultural, and socioeconomic droughts. (Wilhite and Glantz 1985). The lack of a shared boundary concept regarding the definition of a drought seemed to have constituted an obstacle for collaboration and also allegedly hindered the classification as local disaster. The guiding principle for funding in cause of a declared disaster during the emergency (Disaster Management Act from 2002 under section 56) and for post-disaster recovery and rehabilitation, as outlined in the Disaster Management Act from 2002 under section 57, requires assessing: *'whether any prevention and mitigation measures were taken (or initiated by the municipality or province), and if not, the reasons for the absence of such measures; whether the disaster could have been avoided or minimised or whether prevention and mitigation measures had been taken; whether it is reasonable to expect that prevention and mitigation measures should have been taken (or initiated) in the circumstances (by the municipality or province).'* (Republic of South Africa 2002: ss 56 and 57) In this context, it was felt necessary by the stakeholders to develop a shared understanding of the causes that had led to the water crisis: were the conditions or settings for the sudden and severe water shortage humanly induced or a cause of nature? And equally important: could anyone be blamed for the crisis to occur? As mentioned in Chapter 2.5, water resources management is highly political, and especially in case of a crisis, the political dimension becomes visible. Thus the South African Weather Service was respectively asked to provide a definition of a 'drought', and the DWAF was asked to provide historical data on river flows of selected rivers. Whereas the first task could be facilitated easily, DWAF apparently had difficulties in providing the required data. The initial lack of a shared understanding of the term and the concept of a 'drought' as well as the lack of quick provision of historical hydrological data seemed to have constituted an initial obstacle to assess and confirm reasons for the crisis in greater detail, in order to facilitate collaboration and support.

As analysed in great detail in a post-crisis study conducted by Stellenbosch University, it was later confirmed, what at the time during the emergency had slowly to be analysed: *'The period 2008−2011 was reflected in exacting meteorological, hydrological and agricultural drought conditions across the Eden and Central Karoo District Municipalities. These were evidenced by measurable reductions in rainfall, stream flow, groundwater levels and vegetation cover. These reductions were also not limited to a single annual cycle, and spanned at least two to three years.'* (Holloway et al. 2012: Executive Summary 3.1). Further it is stated that: '*Consistent with prevailing studies on drought and water scarcity elsewhere in the world, the severity of the 2009−2011 Eden and Central Karoo drought was amplified by interacting risk drivers that had progressively escalated the risk of a wide-spread water shortage. These included greatly increased water consumption prior to the onset of meteorological drought conditions, both in agriculture and in rapidly growing coastal towns. Prior to the drought emergency, such conditions had been accompanied neither by rigorous water demand management, nor systematic investment in water infrastructure and (in some municipalities) the requisite technical capacity required to manage water supplies sustainably. Water resource development had not kept pace with rising demand. These risks were further exacerbated by a lack of systematic drought risk management planning – especially where this applies to urban settings. Specifically, there was no uniform definition of 'drought', nor were there accompanying indicators that would have allowed for early signal detection and possible early action. Prior to the drought emergency, no indicator-linked contingency plans existed that would have enabled an earlier, 'less resource-intense' response.'* (Holloway et al. 2012: Executive Summary 3.5). 'Drought risk amplifiers' had seriously aggravated the vulnerability of Municipal towns to water scarcity: underfunding of the local Municipality to properly fulfil the role as local water service provider, the related lack of adequate O&M, lack of implementation of leak detection and loss reduction measures, rapid population growth, huge in-migration and related increased water needs had made the local Municipality vulnerable to meteorological and hydrological droughts.

Whereas the local Municipality, as outlined in Chapter 3.5.2, had outsourced numerous studies on extending town water supply and storage systems for increasing general and seasonal needs, decisions never had come through prior to the crisis. In addition to lack of funding, also the clash of concepts of governmental authorities regarding dams as options for bulk water storage in an ecologically highly valued area seemed to have hampered implementation. The technical options had been investigated in extensive detail but decision-making and implementation seemed to have been financially and conceptually deadlocked. During the drought, based on a slow but steady shift of mind-sets and the development of a shared boundary concept on the urgency of the local situation, the settings to ease collaboration were specifically shaped. This included allocation of additional funding, additional resources by various stakeholders in terms of times and expertise to implement joint drought management activities, the development of eased mechanisms for communication and decision-making, reduction of red tape, i.e. postponing environmental licensing procedures for infrastructure projects for the time after emergency.

Break-through for collaboration: It seemed that increasing pressure from local and district level on the provincial and national level based on worsening drought conditions in the entire district (as a natural setting) in combination with a highly engaged Head of Provincial Department had brought the final break-through for collaboration across all governmental spheres during September / October 2009. Since September 2009 the PDMC chaired two stakeholder meetings on a monthly basis: the Provincial Drought Meeting, conducted at the Eden Disaster Management Centre in George, and the Provincial Drought Decision Support Meetings, conducted in Cape Town. These meetings served to bring stakeholders from affected local Municipalities, as well as representatives across all governmental spheres together to assess, monitor and facilitate cooperation and decision-support through improving communication channels. The two stakeholder forums, as ‘boundary objects’, facilitated communication, identification of actions, development of solutions and discussion of emerging challenges of technical, administrative, financial or legal kind. They further served fast-tracking of identified actions. The forums finally merged prior initiatives for stakeholder engagement and advice, such as the 'Technical Task Team' and the 'Strategic Task Team'.

In the meetings, the current water situation in the district was communicated through a tool for 'Water Crisis Management Reporting' – and excellent example for a boundary object − that had been developed under emergency at EDM. The reporting system was based on key indicators on regional and municipal rainfall, hydrological data, water use of local Municipalities, water demand management measures and was published on a monthly basis. The report as information and decision support tool further contained on the front page a risk rating diagram, communicating in a simple way the current risk for water supply shortages for each Municipality within the district (Figure 12):

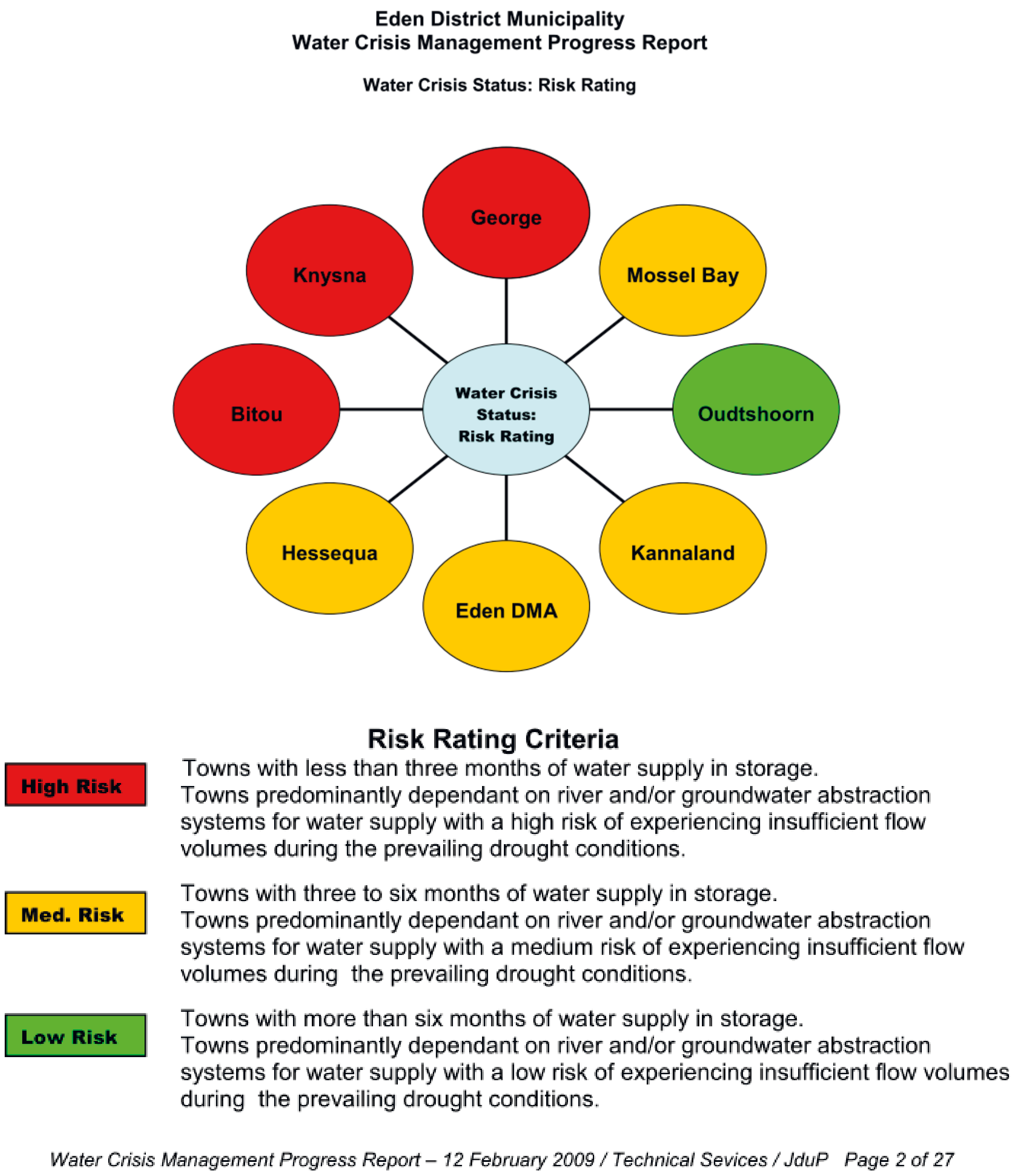


Figure 12 A boundary object: Water crisis management report tool (Eden District Municipality 2009)

Due to its success, the reporting tool was further developed to distinguish between and inform about 'urban domestic and industrial water status', and further 'rural agricultural water status' of the local Municipalities.

In response to the denied request for a disaster declaration by Provincial Government during August 2009, the district Municipality officially applied for financial assistance at Province to mitigate the water crisis, indicating, that if the drought conditions would persist, some Municipalities within the district would have no water for human consumption by the end of December 2009. It must be kept in mind that during that time South Africa was preparing for hosting the FIFA (Fédération Internationale de Football Association) World Cup in June / July 2010. South Africa was expecting numerous international tourists to travel along the Garden Route, which connects Cape Town and Port Elisabeth, two World Cup host cities. At that time, further, three towns within the district, namely George, Mossel Bay and Knysna, were under discussion to host world cup soccer teams and provide base camps for international soccer teams. Facing a situation, half a year before the FIFA World Cup, were Municipalities along the Garden Route would potentially run out of drinking water, has influenced the discourse and stimulated collaboration across governmental spheres.

During October 2009, after Provincial rejection of the request to declare a local disaster, the District Municipality again requested the PDMC to declare a disaster, this time however not just for Sedgefield and the associated rural Rheenendal area, but for meanwhile three local municipalities within the district. On November 4 2009 − almost one year after the crisis in Sedgefield became eminent − the Declaration of the Eden District as local disaster area was approved by Provincial Cabinet, and classified by National Government. This further included a specific local disaster declaration for Knysna Municipality, gazetted on November 20 2009. It however took another 6 months, until the decision of Cabinet of that same day − to also declare the entire Eden District as local disaster area − was enforced by publishing it in the Provincial Gazette on June 11 2010.

Facilitating the disaster declaration thus took almost one year. The long duration of the procedure was based on political structures (dependence on Council resolutions and Provincial Cabinet decisions), administrative and legal requirements (following the required procedure for a disaster declaration without possible shortcuts), no pre-established channels for collaboration in the

Western Cape Province in case of a drought, the lack of a shared definition of a drought, and the difficulties for quick data assessment of drought conditions in terms of the local hydrological situation. This reflects the duration of the process and time frame that was required to develop a shared boundary concept of the local emergency situation across all governmental spheres, to develop informal and formalised boundary objects and to shape the settings to ease provision of support under urgency. Taking so long, it clearly reflects the challenges for collaboration in case of a 'slow onset disaster' under circumstances of non-preparedness by local actors, but also shows, how concentrated efforts by engaged actors can facilitate mitigation.

Boundary objects, facilitating the development of a shared boundary concept and slowly easing the settings for collaboration and communication between January 2009 and September 2009:

- Two strong drivers and bridging agents: the local Municipality Knysna and the Eden District Municipality;
- The 'Report to the Premier' on the conditions of the local water crisis by a provincial Premiers task team;
- An engaged Head of the Provincial Department of Local Government initiating and coordinating activities and launching and chairing two stakeholder forums on Provincial level;
- A tool for situation assessment and decision-support: the Water Crisis Management Reporting System, developed by Eden District Municipality.

Box 11 Core 'boundary objects' during the risk escalation phase: January – September 2009

The role of DWAF: The Department of Water Affairs and Forestry, an actor that was expected to play a crucial and facilitating role during emergency management, was present in the entire process, also actively supported the development of solutions, supported mediation across actors, but seemed to have faced in-house challenges that reduced the Department's effectiveness. DWAFs effectiveness in providing support was challenged by unclear roles and responsibilities of DWAF during the emergency, lack of information on funding mechanisms and related procedures, and again the aforementioned lack of data on registered water use and actual abstraction figures, which was in detail outlined in the Report to the WC Premier (Department of the Premier 2009). Law enforcement and compliance monitoring of high water users at local level needed to be facilitated by the local Municipality through mutual development of relationships with high water consumers, as also no other organisation, such as a Catchment Management Agency, was in place to effectively cover this task during the emergency or in principal.

DWAF's role of significant relevance for the local Municipality during the drought and of high consequences for water supply after the drought was the very early articulated support for selected technologies, i.e. desalination, re-use of effluent and exploration of groundwater sources. It was stated that dams would not be approved, but a 'conjunctive solution' required, thus a mix of technologies for town water supply, with a strong focus on desalination and / or were possible re-use of effluent. This was fully in line with DWAs 'Water for Growth and Development Framework', which was under development (Department Water Affairs and Forestry c. 2009). The framework states in many ways that to mitigate water scarcity a new focus for augmentation of water schemes should be on desalination of seawater and re-use of effluent. However, it is also noted, that heavy investments need to be undertaken (Figure 13) to mitigate water scarcity, were surface water resources are already used to their maximum potential.

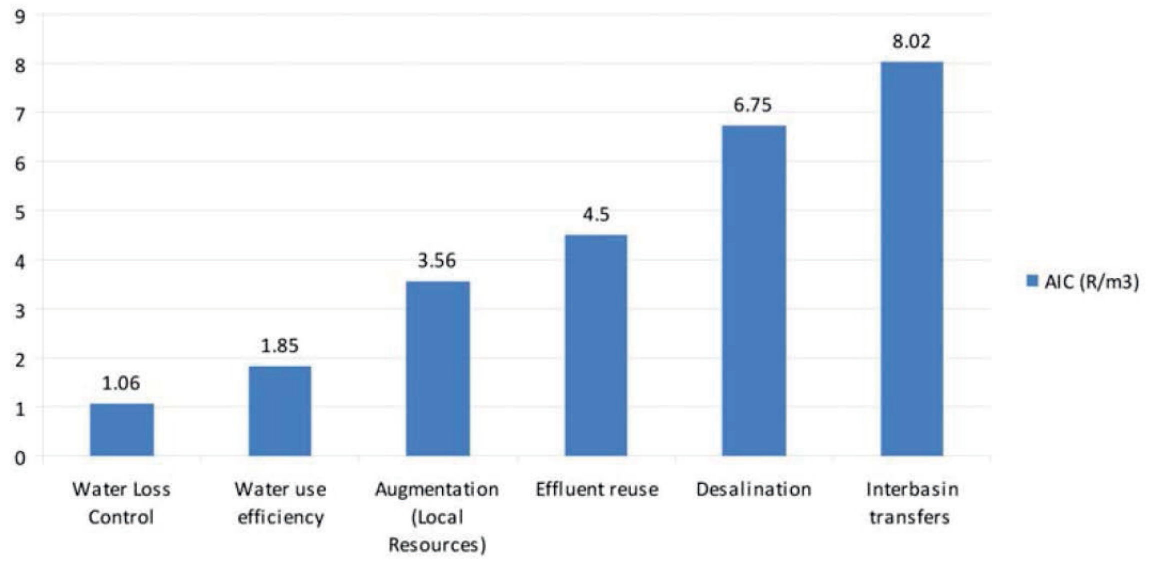


Figure 13 Average incremental cost of intervention measures (Department Water Affairs and Forestry c. 2009: 27)

Considering the lack of resources of local water services providers to operate and maintain their assets, as well as the noted lack of implementing the most feasible option, which is water loss control, raises questions of suitability and sustainability of the new approach. However, due to the lack of Municipal funds to extent town water supply systems, local Municipalities have to apply for any infrastructure measures that are supported by National Grants, whether or not the specific technology is appropriate to local resources in terms of finance and expertise to operate and maintain the infrastructure in the short-, medium- to long-term.

Whereas it was the new policy to support desalination and re-use of effluent, there was yet any experience to draw from. Thus, the emergency situation served for both: implementation of 'state-of-the-art' solutions for water supply as outlined in the new framework and introduction and testing of new technologies at the same time. The particular decisions to support desalination in Sedgefield and Knysna were also based on the outcomes of DWAF's Outeniqua Coast Water Situation Study (Department Water Affairs and Forestry 2007a): the requirements for the legally assigned 'ecological reserve' of the Knysna river, thus the assured minimum flows to sustain ecosystem functions of the river and the estuary are very high and have resulted in a high calculated yield deficit. The yield balance is defined as the '*difference between the as-*

sured yield of the water resources and the water requirements in a specific area' (Department Water Affairs and Forestry 2007a: ix). The study further outlines: '*The Sedgefield / Knysna area (K50) is of the greatest concern with regard to yield deficit. The present-day yield balance for that area indicates a deficit of approximately 10.3 million m3/a, which is expected to grow to about 15.9 million m3/a in year 2025. The water sources should urgently be augmented. The extraordinary high deficit in this catchment is associated with the very high ecological Reserve requirements. Preliminary estimates from the RDM studies currently undertaken by DWAF indicate that if the flow in the Knysna River is greater than 0.5 m3 /s in any month, the estuary requirements will also be met. (…) The development of alternative sources is therefore required. The development of groundwater sources, the use of treated effluent and the desalination of sea water can resolve the deficit problem.'* (Department Water Affairs and Forestry 2007a: 109).

In line with DWAFs emphasis on desalination and reuse of effluent to mitigate the drought, 'diversifying the water mix' was for Sedgefield proposed as follows (Figure 14):

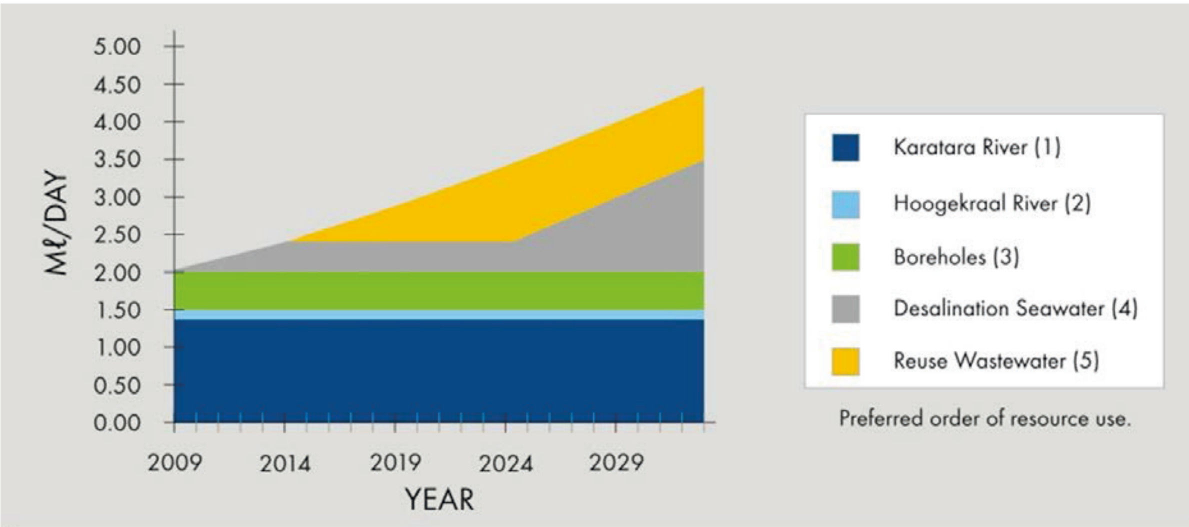


Figure 14 Use of water sources (average daily water production) (Perring et al. c. 2009: 2)

Implementation of storage options, such as outlined in numerous studies before the drought (see also Chapter 3.5.2) that in the long-term would have been easier and cheaper to operate and maintain for the local Municipality, had under emergency not been considered further, but straight in the beginning of the crisis in January 2009, DWAF had noted that they would support procurement of a mobile district desalination plant to be set-up at Sedgefield to assure town water supply. However, since the initial announcement of DWAF to support desalination as technology of choice, in line with the new framework under development, further procedural support from DWAF lacked behind and decision-making got stuck, while the local and the district Municipality had continued to investigate that option in line with DWAFs statement from January 2009. As however further no support was provided by DWAF, finally in September 2009, Knysna Municipality urged DWAF through the district Municipality to come to a decision on the investment and provide concrete financial and procedural support as Knysna Municipality was under severe pressure to assure town water supply over the festive season and during the forthcoming FIFA World Cup. Meanwhile also other funding sources had been identified, but additional co-funding was required to enable implementation. DWAF finally got involved, however, causing challenges by assuring co-funding of 5 million Rand for the desalination plant, which was later-on blocked due to administrative hurdles. In the end, DWAF had triggered the introduction of a new technology in line with their new framework, however, did neither have the resources to provided effective financial, procedural nor technical support for implementation and follow up. Until end of 2009 the major decisions how to mitigate the drought in the research area were taken, funding secured, and implementation of measures initiated or finished, thus other affected Municipalities attracted more notice. Whereas DWAFs involvement in drought mitigation between 2009 – 2011 at the research site was not considered as very effective, the Department got seemingly stronger involved in other Municipalities, such as Mossel Bay, were conflicts between water users, i.e. large scale industry (Petro SA) and farmers were considerably challenging town water supply during the drought. Assessing the role of DWAF during the drought in other municipalities was however not part of this study.

Measures and consequences: During the time of emergency, implemented measures were addressed on two levels: reducing consumption and increasing supply. Especially in the initial period between January and September 2009, when funding was not assured to increase water supply apart from rapid interventions, the focus was on demand reduction. All of the measures for demand reduction can be interpreted as 'boundary settings' and equally as 'boundary objects', as they regulated and communicated the drought conditions between authorities and end-users. The measures to reduce consumption covered:

- severe water restrictions, compliance monitoring and penalty
- technical measures: leakage repair
- intense public awareness campaigns (radio, newspaper, flyers, banners) including publishing the neighbours water consumptions on the water bill
- set-up of an informal stakeholder forum between the local Municipality and local farmers and another forum between the local Municipality and local golf courses. Both forums were also supported by EDM and DWAF, to collect data on water sources and consumption figures, and to opt for 'mutual and voluntary reduction of water demand', as no other mechanisms for proper compliance monitoring of farming and golf courses as high water consumers were established at that time.

After September 2009, as soon as funding was assured, also infrastructure measures to increase supply were initiated. The settings for implementation of infrastructure measures were further eased through an interim agreement with the Department of Environmental Affairs (DEA) whereas construction of the desalination plants in Sedgefield and Knysna could commence without prior environmental authorisation, due to the emergency situation. Section 24F3 of the National Environmental Management Amendment Act, Act No 8 of 2004 (Republic of South Africa 2004) provides for '*illegal commencement of a listed activity*', if the activity *'was commenced or continued in response to an emergency so as to protect human life, property or the environment'* (Republic of South Africa 2004: 24F3). Section 24G of NEMA (Republic of South Africa 1998b) provides for rectification of this *'unlawful commencement of activities'* (Republic of South Africa 1998b: 24G). Thus the implementation of the desalination plants in Sedgefield and Knysna and exploration of groundwater resources could commence without Environmental Impact Assessments (EIA) in the first place, but needed to be rectified after emergency was over. Construction of the desalination plant in Sedgefield began in October 2009 and the plant was operational only seventy eight days after signing the contract, on December 18 2009. At the beginning of October 2009, finance from National Treasury was provided to construct a Reverse Osmosis Plant for Knysna, which was operational on July 16 2010.

The implementation of the two desalination plants faced severe engineering challenges, which was partially assigned to the fact that a new technology was introduced in South Africa and that a respective lack of experience was in place. It was a 'costly learning exercise' for all involved parties, which also holds true for O&M of the plants during the drought and after. As mentioned, due to the enormous pressure to finalise the plants very quickly, facing the peak holiday season in December 2009 and the FIFA World Cup during June / July 2010, both plants were installed under section 24 G of NEMA, thus without prior environmental licensing. Thus reasons for quick infrastructure implementation under emergency were the eased settings in different regards: reduced requirements for public participation processes in the context of environmental licensing; reduced official red tape, usually assigned to such investments; the lack of detailed feasibility studies, assessing the appropriateness and bankability of the projects, including potential risks (ecological, engineering, social, financial) during implementation and later for operation and maintenance. This was due to the lack of time to properly investigate these options, prior to implementation. It had prior not been investigated in greater detail in the context of town water supply studies, as desalination was considered as too expensive, and environmental concerns regarding the brine discharge were high.

Introducing a new technology without the adequate time to properly conduct detailed feasibility studies led to a range of engineering problems that still constituted challenges for proper utilisation of the plants during the time of the research in 2012. In Sedgefield, the quick process led to the wrong site selection of the plant, with the consequence of serious damaging of pipes in September 2011 due to coastal erosion and creating further challenges for damage repair.

Further, desalination is still an expensive way of water production, especially due to the high electricity consumption. In South Africa, there is only one parastatal energy supplier, ESKOM. ESKOM has been widely criticised for holding an energy monopoly in South Africa and related powers to design and implement electricity tariffs. This set-up – a highly energy-intensive technology for town water supply and one South African energy-supplier, holding a monopoly – needs to be considered as risk factor for cost increases for Municipal water service provision.

Apart from the fact that the plants in Sedgefield and Knysna have faced and are still facing serious technical challenges and have been blamed for never having been (fully) operational, the plants have now become a highly expensive though unreliable back-up system for town water supply. Further, the local Municipality has no means to adequately operate and maintain these new assets, which − as outlined in Chapter 3.5.2 – in general holds true for all Municipal assets. The two plants are now creating facts in the discourse of future town water supply for Knysna Municipality and hamper any discussions on investments into other potentially more sustainable and bankable sources for bulk water supply. The situation again seems deadlocked and does not allow for future development within the area, whereas migration and growth in related settlement structures are expected to further lead to increased water needs. Whereas under the emergency situation desalination was the technology of choice, now new structures are required that support the local municipality in making proper use of the new assets, considering that large investments have been made, allocated by all governmental spheres.

In summary, if the following settings are not addressed and shaped, there seems to be no way that the local Municipality as water service provider has a chance to properly manage town water supply in the medium- to long-term to provide equitable and sustainable water to the local citizens in a conjunctive solution:

- Implementing desalination under high pressure and with limited expertise as new, energy-intensive high-tech solutions at a local Municipality under emergency settings without

- Acknowledging that the local municipality has − as a cause of the municipal funding model − no resources for proper operation and maintenance of Municipal assets – thus necessarily quickly deteriorating the costly assets and,
- Leaving the local municipalities with no voice to ask for further support to rectify the decisions taken under emergency by providing additional resources for proper O&M of the plants, or support for installation of locally more appropriate technologies or back-up systems for town water supply.

3.8 Conclusions and Outlook

The research has revealed that despite an excellent setting in terms of water legislation and policy, institutions/organisations[37], mechanisms and strategies to address integrated water resources management based on principles of equity and sustainability on catchment scale in a participatory manner, real-life collaboration at local scale was inherently challenged by local realities. Three phenomena were observed, that constitute core obstacles for collaboration at the research site, and that challenge the future of equal and sustainable water resources management:

Fragmentation: Collaboration happened through numerous scattered initiatives − or boundary objects − around selected topics of concern only, however an integrated approach to water resources management was not in place. This was based on differing concepts of stakeholders on the actual problem definitions at the research site, respectively deviating concepts on management objectives, and further different concepts on management principles that should be applied in local water resources management. Further, there was no effec-

[37] The term ‚institution' is in this empirical study applied in analogy to the local (South African) use and application, meaning 'actors', 'players' or 'organisations', and not, as in the Study of Social Sciences typical, in terms of 'rules', or '*the humanly devised constraints that structure human interaction*' (North 1994: 360). The usual scientific distinction between 'institutions' and 'organisations' (North 1990, 1994) is not applied in the empirical study, to keep the terminology close to the local norm and terminology, as also non-scientific stakeholders are on target group of this study.

tive bridging agent in place and during the time of the research, the hydro-organisational landscape at the study site was challenged by the lack of a Catchment Management Agency. Whereas the area has recently been incorporated into the Breede-Gouritz Catchment management Agency[38], the functionality and effectiveness of this organisational body to facilitate holistic water resources management at local scale needs to be analysed in future. The Department for Water and Sanitation, thus in charge to act as Catchment Management Agency during the time of the research, did not have the resources to facilitate the numerous tasks of a Catchment Management Agency. The core bodies for water resources management that existed at local level, the two Catchment Management Forums, functioned to some extent as bridging agents, but did neither have legal power nor resources to properly facilitate integrated water resources management, and further were not representing the variety of stakeholders on the ground. Especially the lack of previously disadvantaged communities or their representatives was a noted challenge. Fragmentation in itself constituted a major challenge for equitable and sustainable water resources management, as resources could not be effectively pooled, but partially rather worked against objectives of other stakeholders.

Exclusion: It was noted that collaboration was inherently challenged by the noted societal gap between decision-makers and the majority of previously disadvantaged communities. Despite the high emphasis that is put on public participation, effective participation was inherently challenged by three elements: poverty, inequalities and unemployment. The core concepts of previously disadvantaged communities concentrated around 'fulfilment of the basic needs' in terms of access to services, personal security, and health, as these were not fulfilled to different extends. They respectively lacked the 'freedom of choice and action' to participate and contribute (see also Figure 3). Poverty, unemployment and inequalities led to a major clash of concepts between the majority of the previously disadvantaged communities and well-organised and vocal conservation oriented organisations. Conservation oriented organisations dominated the local discourse, centring it around tourism as main eco-

[38] <http://breedegouritzcma.co.za/>, viewed 28 May 2015.

nomic driver, and arguing related needs for nature conservation. However, tourism was not considered to provide stable job opportunities throughout the year, especially not for members from previously disadvantaged communities. Despite the presence of numerous boundary objects that were specifically designed to address this societal split, they mostly faced inherent challenges to effectively bridge across the societal gap. This could be assigned to the scarcity of resources in terms of finance and staff to effectively implement what had been designed (e.g. the Community Development Workers Programme), helplessness to effectively involve local communities in public participation processes (e.g. through catchment management forums, Ward committees or consultation and participation workshops, as e.g. implemented by DWA on the National Water Resources Strategy) or the lack of appropriate monitoring mechanisms that would allow to judge upon and improve the effectiveness of measures, especially on poverty alleviation, like in the case of the extended public works programme ‘Working for Water’. Effective participation of previously disadvantaged communities in public participation processes was generally challenged by a lack of trust into governmental structures in principal and a low level of knowledge, information and confidence to actively engage, also based on a low level of education and literacy. It seemed that the backlog of a (failing) education system had fostered the production and reproduction of societal boundaries and challenged effective participation. The societal gap, characterised by extreme inequalities, poverty and unemployment of the majority of previously disadvantaged communities constituted a major challenge for equitable and sustainable water resources management.

Emergency: It was during emergency, in case of the drought (2009−2011), that collaboration across the variety of stakeholders and across different governmental spheres reached a maximum. During the emergency a shared concept regarding a shared problem definition and definition of management objectives had developed slowly but steadily across stakeholders. A crucial setting for lack of proper integrated water resources management prior to (and also after) the drought seemed to have been the lack of a shared problem definition across stakeholders, and further the lack of resources assigned for integrated water resources management. During the drought however all political levels − from local, district, provincial to national level − assigned additional resources of different scale in terms of time, staff and finances to work on a common objective. Despite the intensive efforts of the local Municipality prior to the drought to amend the town water supply systems to increase water security, and also to allow for future developments and needs, this objective was not possible to be achieved under normal management circumstances. The situation of emergency had created a 'window of opportunity' for the local Municipality to tap additional funding sources and to quickly extend water supply infrastructure under reduced bureaucracy. Additional funding sources constituted an essential setting for extensions of town water supply infrastructure, as the funding model of the local Municipalities under normal management circumstances does not even cater for proper operation and maintenance of municipal assets. During the drought – in line with national strategies − two desalination plants were constructed within the local Municipality. However, based on the introduction of a new technology and respective lack of experience, the desalination plants have been blamed for never having been fully operational. They however now constitute facts in terms of investments made, decisions taken and infrastructure that cannot be reversed, but can also not be operated and maintained in a proper way by the local Municipality. This challenges equal, efficient and sustainable water supply in mid- to long-term at the research site.

The research for this study has revealed the need to develop true boundary concepts on the problems to be addressed at the research site, the objectives to be achieved and the management principles to be applied. There further exists the need for development of proper functioning boundary objects, in terms of bridging agents, processes, mechanisms and products that are specifically designed to acknowledge and redress poverty, unemployment and the distinct inequalities. Facilitating such a process requires a legitimate bridging agent, who could moderate discussions and decision-making. Considering the local 'clash of concepts' between poverty alleviation and nature conservation, despite the extraordinary efforts, experiences (and struggles) to combine exactly these two elements through the nation's 'Working for Water' programme, a legitimate bridging agent should have a conceptual background in both, socio-economic as well as ecological thinking. Experts in the local context, who have knowledge and (limited) resources to facilitate such a process, have rather been noted as purely focusing on conservation outcomes, and would respectively not adequately qualify to bridge across the societal divide.

Acknowledging the strengths and addressing the weaknesses that characterise the local catchment management forums as local organisation and bridging agent at micro-level, it is proposed to re-organise these local bodies to become truly representative and 'trustful' for local communities, to strengthen and rejuvenate them – not by expelling expertise but by attracting younger people to get a chance to meaningfully contribute to an integrated water resources management approach. This would further be considered as easing the multiple and difficult tasks of the Catchment Management Agency.

No strongly established *science-policy* relationship has been observed at the local level, despite this region being of particular interest for different South African Universities. Also strengthened relationships between local actors and international organisations might support approaching the outlined challenges. Further, there is the particular need to evolve a stronger *science-society* relationship, especially across the societal gap to previously disadvantaged communities, and to specifically focus research on the local needs of previously disadvantaged communities and to develop solutions to effectively address these. Currently highly advanced South African research has a very strong emphasis on ecological concerns, and societal or socio-economic concerns seem heavily under-researched, despite these being of high interest of national and local government. Developing a *science-society* relationship – also for instance by addressing research on 'Working for Water' particularly on the societal and socio-economic impacts of the programme, and its particular effectiveness with regard to poverty alleviation – would be seen as facilitating targeted knowledge generation, away from an (almost purely) conservation driven perspective of scientific actors to a broader sustainability and societal oriented perspective, in order to jointly develop 'real-life solutions' to complex societal 'real-life challenges', for a country characterised by inequalities and poverty.

4 GROUNDED DEVELOPMENT OF THE BOUNDARY WORK FRAMEWORK

Sub-question III: Conceptual findings – extending the framework

How can the insights as gained through the empirical and instrumental case study contribute to developing the framework further to support understanding, structuring, communicating and approaching complex water problems through a boundary work perspective?

Box 12 Sub-question III: Conceptual findings – extending the framework

4.1 Introduction and Outline

The following chapter addresses the development of the boundary work framework, and boundary work, based on applying the view of the framework in the empirical study. Chapter 4.2 discusses the conceptual and methodological challenges faced with, when trying to apply boundary work thinking in the case study. Chapter 4.3 elaborates on concrete extensions to the framework based on the empirical insights, and concludes with a proposal for an extended (new) boundary work framework. Chapter 4.4 concludes the analysis and provides an outlook on future research needs.

4.2 Conceptual and Methodological Challenges

As outlined in Chapter 2, the boundary work framework was originally designed to think through complexities of collaboration within inter- and transdisciplinary research projects in the field of natural resources management. In this study, the scope was amended to analysing concepts, objects and settings that supported or hindered collaborative decision-making and action in a real-life setting in a concrete local case. As this was done through individual-type small-scale research, challenges for boundary work, as typically faced within inter- and transdisciplinary large-scale research-teams, were not the focus of this study. Amending the scope required a change of perspectives of the framework, not putting research collaboration, including 'science to science' and 'science to practice' interfaces in the centre of the focus, but the collaboration across stakeholders on the ground and respective challenges for decision-making and management in complex and contested situations of natural resources management.

Applying the framework for system's assessment required the development of a complex methodology for data collection and analysis that gave consideration to both – empirical as well as conceptual lines of research. Grounded theory produces systemic abstractions, not accurate descriptions of encounters or findings and doing so conceptually as well as empirically required constant complex analytical double-tracked thinking: What can I learn about the local situation by trying to structure challenges for collaborative water resources management into concepts, objects and settings? What can I learn about the framework, by trying to apply it in an empirical analysis? Thus inductive coding was initiated to start revealing phenomena that characterized collaborative water resources management at the study site, to unpack structural diversity and complexity. Over the time of data analysis and as hypotheses about collaboration started to emerge, this was complemented by deductive coding procedures for the empirical analysis. Simultaneously deductive coding was applied from the beginning to conceptually learn something about the boundary work framework.

The enormous data base contained thousands of pages of primary data, several thousands of pages of secondary data, and the complex analysis led to several hundreds of codes for emerging hypotheses. Data analysis was not only conducted with the help of a software to deal with complex qualitative electronic data bases, but was supplemented through analogue 'paper and pencil' modes of analysis, including writing and re-writing of hypotheses, restructuring and re-coding of data, as new insights emerged.

4.3 Insights from the Instrumental Case

4.3.1 The framework: Challenged by reality

The first finding was that the theoretical approach for South African water resources management could relatively easy be captured in the view of the boundary work framework: The National Water Act defines boundary concepts for water resources management in terms of management objectives (the water resources must be protected, developed, conserved, used, controlled and managed) and management principles (equity, sustainability, efficiency; integration and participation). Together with the Water Services Act and the National Environmental Management Act it provides the legal settings for South African Water resources management. It further caters for the development of boundary objects, in terms of bridging agents, mechanisms, participatory approaches and products, in line with three levels of increasing decentralisation (Table 17). The different boundary objects for each tier shall further facilitate the development of shared boundary concepts on management objectives and principles at lower levels of WRM, as outlined in Chapter 3.4.1.

Table 17 Boundary objects in the water resources management framework

Tier	Type of Boundary Object	Specify Boundary Object
First tier (national level) *(cont)*	Bridging agents	Ministry and Minister of Water and Sanitation
		Department of Water and Sanitation
	Mechanism	Development and regular review of the National Water Resources Strategy
	Participatory Processes	Stakeholder Consultation on the NWRS
	Products (selected)	Guide to the National Water Act (Department Water Affairs and Forestry n.d.a)

Tier	**Type of Boundary Object**	**Specify Boundary Object**
		Water Management Institutions Overview (Department Water Affairs and Forestry n.d.b.)
Second tier (nine water management areas)	Bridging Agents	Catchment Management Agency (and related monitoring and advisory bodies)
	Mechanism	Development and regular review of the Catchment Management Strategy (CMS)
	Participatory Processes	Stakeholder Consultation on the CMS
	Products (selected)	Establishing a Catchment Management Agency – Guide 1 in the CMA/WUA Guide Series (Department Water Affairs and Forestry c. 1999a) Guidelines for Catchment Management Strategies – towards equity, sustainability and efficiency (Department Water Affairs and Forestry 2007b)
Third tier (Water User Associations)	Bridging Agent	Water Users Association
	Participatory Processes	Regular water user meetings
	Products (selected)	Establishing a Water User Association – Guide 3 in the CMA/WUA Guide Series (DWAF c. 1999b)

Tier	Type of Boundary Object	Specify Boundary Object
Non-statutory bodies	Bridging Agent	Catchment Management Forums
	Participatory Processes	Regular stakeholder meetings
	Products (selected)	Guidelines on the Establishment and Management of Catchment Forums in support of integrated water resource management (DWAF 2001)

However, it was a noted fact that implementation of this excellent theoretical framework was facing considerable challenges, not only at the study site but throughout the country, which had been analysed in multiple ways (Schreiner and Hassan 2011, Schreiner 2013). Schreiner summarised her detailed findings as follows: ‘*The South African Water Act was (…) hailed internationally as the Rolls Royce of IWRM legislation. But implementation has proved extremely difficult. It would, perhaps, have been better, to write a Volkswagen piece of legislation, one that is more suited to the technical and human resources capabilities of a developing country*.’ (Schreiner 2013: 244).

This relates to an empirical core finding that challenged the conceptual application of the boundary work framework in the empirical study: the ‘real-life jumble’ on the ground did not let itself capture easily through the view of the framework. The boundary work framework was further not designed to capture the extreme societal dichotomies and gaps that characterise South Africa: on the one hand there was a South African intellectual elite that developed world-class policy and legislation, on the other hand there were no resources in terms of effective organisational bodies, finance and capacities to facilitate implementation on the ground, and a noted gap between decision-makers and the majority of previously disadvantaged communities, despite the high emphasis on public participation across the societal divide.

4.3.2 Abstracted phenomena: The conceptual superstructure

This leads over to the challenges faced, when trying to apply the framework for assessment of reasons and obstacles for collaborative WRM in the local case. The multiplicity of stakeholders and perspectives, the lack of real boundary crossing concepts and objects, theoretically great tools for joint decision making and public participation − but the lack of proper application of these boundary objects in local practice, challenged the perspective of the framework. The complex situation on the ground did not show itself through boundary concepts, objects and settings. It was only after having revealed a first ‘superstructure’, in terms of abstracted phenomena that characterised local water resources management (fragmentation, exclusion, and different dynamics under emergency) that the framework started to develop strength to capture reasons and obstacles for collaborative WRM for each of the derived phenomena, however to different extents and with different methodological challenges:

The phenomenon of fragmentation could be captured through the view of the framework, however, less by identifying unifying elements, but by revealing, what challenged a shared perspective and effective collaboration in terms of concepts, objects and settings.

The phenomenon of ‘exclusion’ was initially inherently challenged to be captured through the view of the framework: boundary work implies that there are ‘boundaries’ or ‘barriers’ between stakeholders, and these shall be analysed, approached and dissolved. However, the encountered inequality produced societal gaps instead of boundaries, especially between decision-makers and the previously disadvantaged communities and the framework was not designed to capture these gaps. However, by ‘reversing’ the perspective of the framework, it became of great use to reveal challenges for collaboration: it was reversibly applied to assess how functionality of boundary objects was challenged by this gap, how concepts clashed and thus did not facilitate collaboration across the gap, and how gaps were manifested and reproduced through local settings.

It was only under emergency, during the drought 2009 – 2011, that the framework could again easier be applied to capture the local situation in terms of concepts, objects and settings. Pressure however did not bring the local modes of collaboration closer to the 'ideal and formal case' as outlined through policy and legislation, as the basis in terms of organisations and capacities to cater for this was not properly functional. Collaboration during the drought was initially rather informal, until each stakeholder had found its role and until modes of collaboration had been developed and formalised. By then, a true boundary concept had been developed, boundary settings were shaped and collaboration was eased through boundary objects, as outlined in Chapter 3.7. As soon as the real emergency situation was over, collaboration developed into the phenomenon of conceptual fragmentation, as outlined in Chapter3.5.

4.3.3 Extending the notion of concepts, settings and objects

Relatedness of concepts and settings: Data analysis supported the rationale of discussing concepts and settings in connection to each other, as they proofed to be closely interrelated. Mollinga categorises boundary concepts as 'knowledge for understanding' and boundary settings as 'getting the institutional arrangements right'. It was difficult in empirical research to clearly distinguish between concepts and settings. Concepts could often be explained or understood by analysing the external and internal organisational settings of a stakeholder. As the two elements seem to be closely interrelated, it is proposed to change the order of the elements of the framework to '*concepts, settings and objects framework'*, to show the relatedness of the two elements.

Extending the notion of boundary concepts: In Chapter 2.6.1 two types of boundary concepts were defined when assessing problems of collaborative water resources management: a) Boundary concept on *terminology* and boundary concepts on *management principles.* Empirical research revealed that this classification was too simple to capture reasons and obstacles for collaboration in real life. Mollinga defines boundary concepts as '*words that function as concepts in different disciplines or perspectives'* (Mollinga 2010a: 4) and classified boundary concepts through commonly shared 'terminology', associated meanings and interpretations. The empirical study revealed examples for boundary concepts in this sense, however, most boundary concepts were only shared across few stakeholders and did not bridge across the majority of stakeholders. Examples for 'words as concepts' that were of relevance in the local context, however not equally shared across stakeholders, were the following: Most stakeholders stated that **integrated** approaches would be required in local water resources management, and lacking in reality. However, the concept of **'integration'** – the question who should be integrated and how integration should happen – considerably varied across stakeholders. Further examples for boundary concepts were the terms **'equity'** and **'sustainability'**, and associated meanings. However, although definitions of these concepts as management principles were provided through the National Water Act (Republic of South Africa 1998), the reality proofed a variety of different interpretations of both terms. The only true boundary concept that was revealed during research that really was shared across the majority of stakeholders was the concept of the **'drought'**. The emergency of the situation had produced pressure over a longer lasting period that supported the development of a shared concept of a problem definition among stakeholders.

Research revealed that boundary concepts could actually be clustered in line with a superior structure. Reasons and obstacles for collaborative local water resources management were based on differing concepts on three levels:

- **Concepts on problem statements:** It was found that the diversity of concepts already started with the actual problem definition. Collaborative decision-making and action was inherently challenged by the lack of a shared understanding of definitions of local water problems at two levels: the multiple stakeholders had very different concepts of what constituted the core water problems to be addressed in principal (access, supply, allocation, pollution or else) (see Chapter 3.5 and 3.6), or − when addressing a shared problem, as during the drought − the lack of a shared definition of the same term. Although stakeholders used the same term to discuss a local water problem, interpretations of the term considerably varied, which hampered collaboration, and a shared understanding of the problem definition still needed to evolve (see Chapter 3.7). Fostering collaborative action thus requires developing a) a shared understanding of the actual problem(s) to be addressed in general, and

b) assuring that all stakeholders associate the same concept with the same terms, thus working with shared definitions.

- **Concepts on management objectives:** It was further found that in line with the differing concepts on problems statements, concepts also deviated with regard to the actual management objectives for local water resources management (see Chapter 3.5). To foster collaboration, boundary concepts on the 'management objectives' need to be jointly developed.
- **Concepts on management principles:** Empirical research further proofed a variety of concepts on diverging management principles for local water resources management in general, or different interpretations of same 'words' that should function as management principles, such as 'integration', 'equity' and 'sustainability'. Also this constituted challenges for collaboration. Supporting collaborative decision-making and action requires the development of a shared understanding of management principles to be applied in general, and an assurance that all stakeholders share the same definitions of the commonly used terms. It is further recommended, to define management principles at different levels of water resources management and governance: universal principles for WRM, as in detail defined in Chapter 2.6.1, should provide a (new) overarching framework for WRM in general. However, for working in real-life WRM, concepts on management principles need to be broken down to different levels of governance and management, but always in line with the nation's general principles, as outlined through South Africa's water resources management framework.

Extending the notion of boundary settings: In Mollinga's framework, 'settings' are defined in the context of transdisciplinary research projects: *'To flourish, inter- and transdisciplinary research need a conducive environment. This environment can be divided in two, interrelated parts, together forming the boundary settings of a research project or program: 1) the **internal** organization and dynamics of the specific research activity; 2) the broader **external** environment of that activity'* (Mollinga 2010a: 6−7). This perspective needed to be changed to be of conceptual appropriateness for the empirical study. Boundary settings in this research project were not analysed with regard to a research-centred perspective, but with the focus on the real-life challenges and politics in collaborative water resources management in a local case. Empirical research revealed that settings influencing collaboration of stakeholders played out on three levels:

- **External settings** were considered as the 'wider framework conditions' that shaped the situation at the research site. This includes socio-economic, cultural, political, legal, ecological and technical features. It further includes 'institutions' as defined through the social study of sciences. External settings were considered as changeable only in longer terms (see also Figure 5 for the duration of selected 'external settings' to change).
- **Organisational settings** defined the basis for stakeholder's willingness and ability to effectively collaborate with other stakeholders. These for instance referred to the role and mandate of an organisation (legally assigned or outlined through a constitution), available resources in terms of funding, staff and expertise, time and also availability of data and information.
- **Individual settings** of stakeholders did work twofold: in line with or against organisational settings. Collaboration was at the local level strongly influenced by individual settings of people, based on their positions, individual background and attitude.
- **Natural and technical settings:** A third cluster of settings of influence referred to natural and technical settings. Natural settings of influence were topography, hydrological and meteorological settings; technical elements of relevance included water supply and wastewater treatment infrastructure.

Extending the notion of boundary objects: In Chapter 2.6, a new classification for boundary objects has been discussed. It was proposed, to classify boundary objects in line with four categories: boundary organisations, processes, tools and products. Comparing these categories with empirical findings, it is proposed to amend the notion of boundary objects in the following way:

- **Bridging agents:** Instead of boundary organisations, it is proposed to rather categorize 'bridging agents' in general. This includes formal or informal organisations, groups or individuals that bring together diverse stakeholders and facilitate a bridging process across diverging interests. This covered formal boundary organisations, as e.g. Catchment Management Agencies, or in case of the drought the Eden District Disaster Management Centre and the Provincial Disaster Management Centre. It further included groups or individuals that informally initiated exchange in cases of conflicting or diverging interests. Informal grouping e.g. happened in various cases during the drought, where individuals as bridging agents stood out and opened up initiatives to discuss diverging interests. This related for instance to the multistakeholder forums, as initiated by the Head of the Provincial Department of Local Government (see Chapter 3.7). Also the local CMF acted as important bridging agent, however neither properly formal nor informal, as they were no statutory body of integrated water resources management, however in their general importance acknowledged by the Department of Water and Sanitation.
- **Processes:** Numerous boundary objects in terms of boundary spanning processes could be identified. Mollinga classified: '*In practice, three different routes or strategies for inter- and transdisciplinary knowledge integration can be identified: the analytical route of conceptual and theoretical modelling, the assessment route of pragmatic frameworks for mapping and assessment, and the participatory route of communication and negotiation for social learning and transformation'* (Mollinga, 2010a: 5; for details see Mollinga 2008b). Chapter 2.6.2 follows this classification and also sub-categorized boundary spanning processes, based on their route of knowledge development, into analytical processes, assessment type and participatory processes. Whereas these categories fit the original scope of the framework to assess boundary work within inter- and transdisciplinary research projects, they could not be confirmed

in the empirical study. In the **'analytical route'**, Mollinga focuses on 'modelling' as science–driven boundary object. Especially when modelling complex socio-ecological systems behaviour, the process of model development ideally brings together multiple actors from science, policy and practice and can serve as boundary object in terms of a bridging process. This type of complex, highly academic modelling exercise could not be observed in the research area, but Mollinga also stated that '*the track record of such science-driven decision support tools is rather weak, that is, very few make it to active actual use, at least in less-developed countries.*' (Mollinga 2008a: 28). Mollinga's **'assessment route'** refers to the development of (assessment) frameworks, which bridge between science and policy. In principal there was no strong science-policy relationship visible in the study area. However, numerous frameworks were of relevance for local boundary work processes, but less in Mollinga's interpretation, as matrices and flow charts, but in terms of policy documents, regulating and outlining planning and decision-making processes in line with certain principles and communicating them across different governmental spheres (local, district, provincial, national). Examples for this were the Water for Growth and Development Framework, (Department Water Affairs and Forestry c. 2009), or the Spatial Development Framework (Knysna Municipality 2008). These frameworks served as boundary objects, but rather in terms of 'products', less in Mollinga's sense. Both routes (the analytical route and the assessment route) were as such not of specific importance in the local context, and conceptually remained weak. However, almost all local processes as encountered could be categorised under Mollinga's **'participatory route'**, which was also based on the great emphasis that public participation was receiving in South Africa. Empirical research strongly confirmed the participatory route as tool to bridge across actors and interests. It is proposed to further subcategorise the 'participatory route' according to the objective and envisaged level of involvement in the participatory process, in line with Ridder et al. (2005). Ridder et al. (2005: 1–2) distinguish between three different levels of participation: '**Information'** reflects the lowest level of participation, by '*providing access to information and disseminating information actively*'; **Consultation** '*means that the public can react to government proposals. In many planning procedures it is legally required to publish drafts and allow the public some time to make comments in writing. Other forms of consultation include oral consultations and surveys.*' **Active Involvement,** as highest level of participation '*implies a more involved role for the public, by have discussions with authorities, help to determine the policy agenda, help to develop solutions, be involved in taking decisions and participate in implementation, become fully responsible for (part of the) river basin management.*' (Ridder et al. 2005: 1−2). It was observed in practice that misunderstandings during public participation processes, as encountered for instance during DWA's workshop on the NWRS II in the local township (see Chapter 3.6.1) were mainly based on different concepts on the objective of the workshop: whereas the previously disadvantaged communities interpreted the workshop objective as 'consultation', DWA's intention was rather to share 'information'. Effectiveness of the participatory route requires all stakeholders to share the same understanding of the expected level of involvement of participants in a particular process.

- **Mechanisms:** It was noted that the category of 'tools', as previously proposed, turned out not to be precise enough for the analysis. All boundary objects (bridging agents, processes, products) are 'tools' to facilitate boundary work. Empirical research confirmed rephrasing to **'mechanisms'** rather than tools. Mechanisms as boundary objects could refer to programmes, such as ´Working for Water', or for instance to demand management mechanisms as implemented during the drought.
- **Products:** Products refer to reports, figures, graphics or else, that present knowledge and information and facilitate communication. These products serve to discuss and bridge between policy makers, scientists, practitioners and interested citizens. An ample range of products had been developed to translate South African water policy and legislation to

the people, and also to communicate on the specific local situation (for instance the IDPs on local and district level, or DWA's town water reconciliation strategies) and confirmed this category.

4.3.4 Making it happen

As outlined, the empirical research did not aim to test and advance the process to design and facilitate boundary work in complex and contested situations of water resources management, as proposed under Chapter 2.7.3, but to analyse reasons and obstacles for collaboration in a local case and to advance the conceptual notion of boundary work. Nevertheless, the empirical study also provided some insights into the appropriateness of the proposed process. Although the process reflects the state-of-the-art in transdisciplinary research as well as adaptive management, the local reality seems to contain inherent challenges to effectively implement such a boundary work process. This is based on a developmental context which is characterised by extreme inequalities, a scarcity of (water) experts in general, and greatly diverging levels of knowledge and education of civil society, which is expected to play an active role in participation processes. Whereas the level of expertise in South Africa regarding adaptive management, here the approach of Strategic Adaptive Management (SAM), is internationally highly advanced, and action-research on implementing an 'adaptive management approach' at catchment scale had been implemented by the Centre for Water in the Environment, University of the Witwatersrand together with the first operational Catchment Management Agency, the Inkomati CMA (ICMA) (see Rogers and Luton 2011), the local reality at the research site did not seem to provide a basis in terms of capacities and resources to cater for such a process at this stage, if not with considerable external input (expertise and finance), as provided in the example of the ICMA.

Based on the greatly diverging levels of knowledge, information and education as encountered at the local level, it was found that functioning boundary objects to communicate reasons and obstacle for collaboration, as revealed through this study, specifically addressing different levels of expertise, would provide a helpful basis to facilitate exchange between stakeholders, as basis for improved collaboration.

4.4 Conclusions and Outlook

The boundary work framework provides a useful analytical basis to assess and reflect upon boundaries for collaboration across stakeholders in complex and contested water resources management problems in a structured manner in a local case. However, some elements had to be amended, before the framework could be applied:

First, the notion of the framework had to be tuned to be of use for the empirical study, away from its original intention to assess and stimulate processes of boundary work in inter- and transdisciplinary research projects, but to assess and facilitate boundary work in a developmental decision-making and management context. Second, the complex situation on the ground did initially not show itself through boundary concepts, objects and settings. It was only after having revealed a first 'superstructure', in terms of abstracted phenomena that characterised local water resources management (fragmentation, exclusion, and different dynamics under emergency) that the framework could develop its strength to capture reasons and obstacles for collaborative WRM for each of the derived phenomena. This allowed developing the notion of boundary concepts, settings and objects further:

Boundary concepts: The analysis of boundary concepts provides conceptual insights, why stakeholders may or may not opt to collaborate with each other. To better understand, what drives actors towards collaborative water resources management it is proposed to categorise the following boundary concepts:

- **Concepts on problem statements:** analysis and development of a shared understanding of the problem(s) to be addressed. These concepts can further differ for different scales or levels of water resources management or governance.
- **Concepts on management objectives:** analysis and development of shared concepts on the 'management objectives' of collaborative deci-

sion-making and action. These concepts can further differ for different scales or levels of water resources management or governance.

- **Concepts on management principles:** analysis and development of shared boundary concepts on management principles to be applied. Management principles need to be defined for different levels of water resources management and governance: universal principles for water resources management, as in detail outlined in Chapter 2.6.1, should provide a (new) overarching framework for water resources management in general. When working in real-life water resources management, concepts on management principles need to be further broken down to different levels of governance and management, but always in line with the nation's general principles, and ideally in line with the overarching management principles.

Further, there is the general need to assure in any communication that the same concepts are associated with the same words, thus the need for shared **concepts on terminology.**

Boundary settings: Boundary concepts and settings are closely interrelated, as settings often shape the concepts of stakeholders. However, settings are considered as largely 'given' and very difficult to address, even within medium- to long-term planning horizons. A better understanding of boundary settings helps, to understand limits and limitations for collaboration. Settings could be classified according to five categories:

- **External settings:** cover socio-economic, cultural, political, legal, ecological and technical framework conditions at larger scale, e.g. the region or the nation.
- **Organisational settings** refer to the role and mandate of an organisation − as legally assigned or also outlined through a constitution, and available resources in terms of funding, staff and expertise, time, data and information. Organisational settings shape the ability and willingness of stakeholders, as members or employees of specific organisational bodies, to collaborate with others.

- **Individual settings** of stakeholders (position, background, individual attitude) can work twofold, in line with or against the organisational settings, but are of great importance for success or failure of collaboration.
- **Natural settings** refer to natural elements of socio-ecological systems (hydrology, topography, meteorology and others) and constitute facts that shape concepts and discourse and thus need to be taken into consideration.
- **Technical settings** cover technical (infrastructure) elements of relevance, such as supply and wastewater treatment infrastructure, and also constitute facts that shape concepts and discourse.

Boundary objects: Boundary objects are tools that facilitate communication and collaboration between stakeholders. It is proposed to categorise boundary objects as follows:

- **Bridging agents** refer to (formally or informally developed) boundary organisations, groups, or individuals that facilitate communication and collaboration of stakeholders to bridge between different interests.
- **Participatory processes** as boundary objects refer to processes that based on different levels of stakeholder involvement, aim to purely *inform, consult* or *actively involve* stakeholders in planning and decision-making.
- **Mechanisms** as boundary objects cover programmes, or incentive mechanisms that communicate a need and set incentives to collaborate.
- **Products** are boundary objects in terms of reports, figures and graphics or else, that present knowledge and information and facilitate communication.

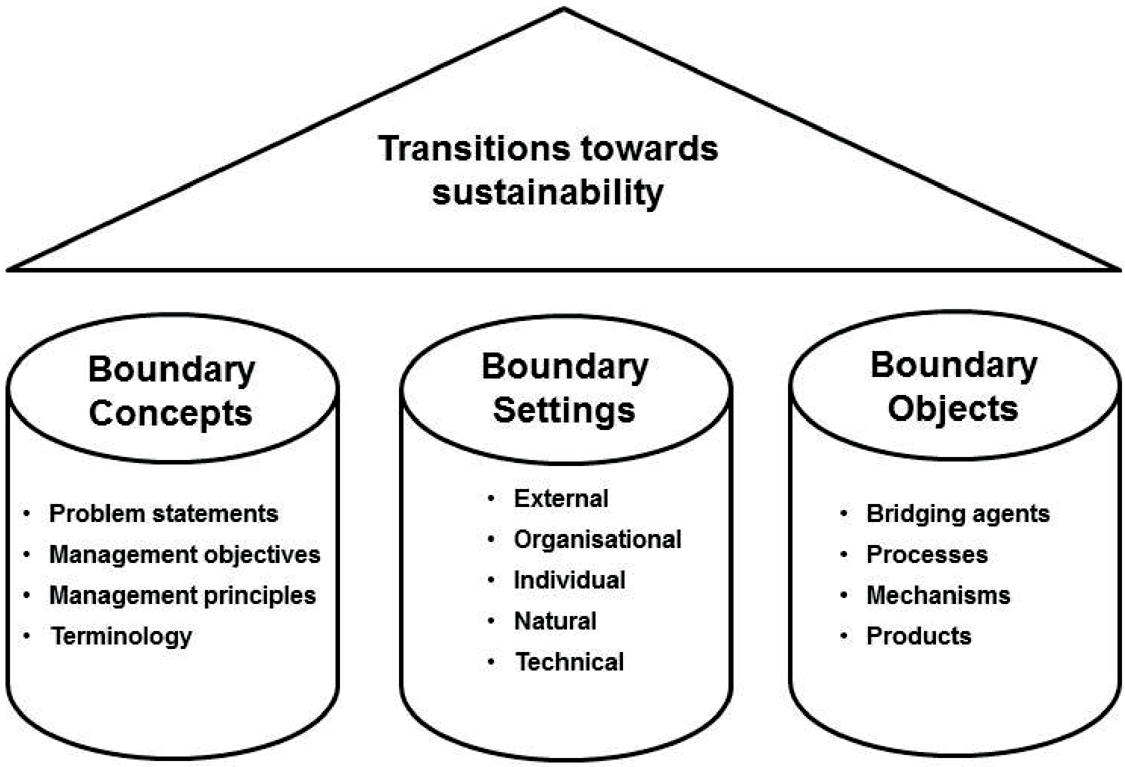


Figure 15 The extended (new) boundary work framework

Making it happen: The situation at the study site provided some insights into the appropriateness of the proposed procedure to facilitate boundary work. The local situation in this developmental context would at this stage only cater for such a process, if considerable external input (expertise and finance), would be provided. There is no way, that this could be facilitated by own (local) means. Second, based on the high level of inequalities as encountered at the study site, not only in relation to income, but also to knowledge, confidence, livelihoods, expectations or else, the need for boundary objects that are specifically adapted to these settings, became obvious. A participatory process for boundary work would require an explicit focus on the development of appropriate boundary objects that facilitate communication and collaboration across this extreme societal divide, to be able to function. Third, such a process requires a legitimate bridging agent, which in the local setting was yet not existent, however, some local organisations, like the Catchment Management Forums could provide the basis to be organisationally developed, to be able to facilitate a similar process. Thus, the process, as proposed in Chapter 2.7, requires all the above elements to be considered to get a chance to function in a similar developmental context.

Future conceptual as well as empirical research is needed, to assess interlinkages and potential contributions of the emerging field of boundary work science to the scientific fields of sustainability science, transition research and transition management, which further embraces (strategic) adaptive management approaches and transdisciplinary research. Research is required with a stringent focus on developmental contexts and contexts characterised by explicit socio-economic inequalities. Further research is recommended to derive success factors for boundary work: in line with the focus of this study, these should be developed aiming at boundary crossing in 'real-life' situations of complex and contested decision-making and management, also across societal gaps.

5 FINAL CONLUSIONS AND OUTLOOK

This study aims at advancing boundary work science in the context of complex and contested water resources management problems with a focus on developing countries. The objectives of the study play out on a conceptual as well as on an empirical level. Conceptually, it is reflected, how the boundary work framework (Mollinga 2008a, 2008b, 2010a) can be used to analyse, structure and design boundary work processes in complex and contested water resources management problems, with a contextual focus on developing countries, by clustering boundary work processes into boundary concepts, objects and settings. Based on the analysis of leading approaches in water and natural resources management (i.e. Integrated Water Resources Management, Adaptive Management, the Ecosystem Approach) through the view of the framework, Mollinga's framework is conceptually extended. Whereas Mollinga has classified boundary concepts in terms of '*terminology*' that needs to be shared across actors, it is proposed to extend the notion by further classifying boundary concepts into *'concepts on water resources management principles'* as well as *'concepts on terminology'*. It is further proposed to change the notion of boundary objects as developed by Mollinga and to categorise boundary objects in terms of *organisations, processes, tools and products*. Mollinga's notion of boundary settings is kept, by dividing into *'external' and 'internal settings'*. Further, a proposal for a procedure, how to approach boundary work in complex and conflictive situations of water resources management from scratch, is developed, based on insights from Adaptive Management, Transdisciplinary Research and the Ecosystem Approach.

Following the conceptual amendment of the framework, a case study was conducted at the Garden Route region, South Africa, by applying the developed (new) boundary work perspective as model of thought in the assessment of a complex real-life situation of (conflictive) water resources management. It was investigated, what supported or hampered collaborative water resources management in the local case by analysing boundary concepts, objects and settings that influenced collaborative water management and decision-making at local level. The case study is both, intrinsic, as well as instrumental: intrinsic, as it provides inherent insights into reasons and obstacle for collaborative water resources management in a 'real-life' management situation, and instrumental, as it serves to test and further extend the boundary work framework as contribution to transition management, transition research and sustainability science. The real-life situation under 'normal' management circumstances proofed to be characterised by fragmentation of stakeholders and exclusion of the poor, the so called 'previously disadvantaged communities' from water resources management, despite their integration being of utmost political importance in post-apartheid South Africa. Factual exclusion was based on the very high levels of inequality, poverty and unemployment that characterise not only the situation at the study site, but South Africa in general. Collaboration across stakeholders was inherently improved under severe water stress, as encountered during the drought that lasted from 2009 – 2011. The severity and duration of the situation allowed the development of shared boundary concepts across stakeholders, the shaping of settings to ease collaboration and the development of effective boundary objects over time. However, emergency led to new town water supply infrastructure, i.e. two desalination plants that were implemented under high pressure, with limited time and limited expertise, as a new technology was introduced to the country. These assets are now not considered to be fully appropriate to be operated and maintained by the local Municipality, as water service provider, based on the lack of resources. The situation of improved collaboration under pressure developed into the 'normal' incident of fragmentation and exclusion, after the drought was over.

Based on the findings of applying the boundary work framework in the empirical study, further extensions to the framework are developed. It is found that the framework is suitable to develop its conceptual strength only, after abstracted phenomena that locally characterised collaborative water resources management, in terms of fragmentation, exclusion, and different dynamics of collaboration under pressure, have been identified. It is then analysed, that diverging concepts, influencing modes of collaboration, actually play out in three categories, namely diverging concepts on problem statements, management objectives and management principles. These all need to be further specified and developed for different scales of water resources management and governance. It is further confirmed that a principal requirement for effective communication and collaboration between stakeholders is to assure that each stakeholder associates similar 'concepts' with the same 'words', thus works with shared concepts on 'terminology'. This necessity equally holds true for all of the three categories of boundary concepts. It is further found, that boundary concepts and boundary settings are closely interrelated, as settings often influence the prevailing concepts, and thus it is proposed to change the order of the elements within the boundary work framework, to '*concepts-, settings- and objects-framework'*, to show the connectedness of concepts and settings. Settings of importance in the local case play out in five categories, namely external, organisational, individual, natural and technical. It is further proposed to change the categories of boundary objects into bridging agents, participatory processes, mechanisms and products. The analysis further allows some reflections on the appropriateness of the proposed procedure for boundary work. It is found that the local reality, characterised by high levels of inequality, poverty and unemployment would require the following elements, to allow for a boundary work process to function: provision of external resources, in terms of funding and expertise to moderate such a process, an explicit focus on the development of boundary objects, that bridge across the societal divide, a legitimate bridging agent, focussing on both: poverty alleviation and conservation outcomes, and strengthening of existing organisations at micro-level, that already partially function as bridging agents, such as catchment management forums.

South Africa's Gini coefficient, as index for income inequality, is among the highest rankings worldwide. The extreme income inequality as well as socio-economic dichotomy in general, as encountered at the research site, proofed to require methodological creativity to access both – the rich as well as the poor. Income inequality went along with extreme inequalities in almost all parts of life and further related to knowledge, power, education, livelihoods, expectations, confidence and means to participate in public debates. Sustainability science or transition research and management so far either focus on economically wealthier countries, or purely on the poor. I had however not come across research approaches in these fields of science that addressed this extreme socio-economic dichotomy in terms of poverty next to holiday homes and golf courses, when unpacking challenges for sustainable development. This reality questions integrated and sustainable water resources management, by touching matters of fulfilment of the basic needs of a great majority versus an explicit and high emphasis on the protection of water and other natural resources by a powerful minority. It further questions the 'equal chances' to participate in and shape decision making for everyone, as required by the national water resources management framework. These contradictions are partially addressed through Maslow's Hierarchy of Needs theory and research is needed to study correlations between Maslow's theory and explicit challenges for transitions towards sustainability in developmental contexts characterised by extreme inequalities. This was not deepened in this dissertation, but could be deepened through future research. Developmental contexts often embrace the top and the bottom end of the pyramid within the same 'socio-ecological system'. Facing dichotomy and exclusion raises questions on the meaning of public participation in such a developmental context, characterised by extreme inequalities. The following reflections on future research needs are placed in the context of this core finding of the study:

Conceptual research: It is recommended to further analyse interlinkages and potential contributions of the emerging field of boundary work science to the scientific fields of sustainability science, transition research and transition management, which further embraces (strategic) adaptive management approaches and transdisciplinary research. Research is required with a stringent focus on developmental contexts and contexts characterised by explicit socio-economic inequalities. Further research is recommended to derive success factors for boundary work: in line with the focus of this study, these should be developed aiming at boundary crossing in 'real-life' situations of complex and contested decision-making and management, also across societal gaps.

Empirical research: To advance the developing field of boundary work science, further empirical case studies are required at different scales, with different levels of interaction with and between stakeholders in varying (developmental) contexts. It needs to be elaborated, which types of case studies are appropriate for specific lines of research. Based on the reflections of this study, it is proposed, to either – as done in this intensive small-scale research − focus on an in-depth study of a local case, or alternatively, if implemented at large scale, focus on design, implementation and analysis of processes of transformative change, based on transdisciplinary research and adaptive management approaches. For both types of studies there is an inherent need to focus future research on developmental contexts and on contexts characterised by extreme socio-economic inequalities. Case studies should be:

- **Exploratory / experimental / interactive:** Case and methodology are not specified in advance but are evolving during research in order to support the development of framework and procedure. The level of experimentation and / or interaction depends on scale and resources of the research project.
- **Embedded:** The case covers several units or objects of analysis, as required in complex and contested problems. Usually this implies incorporating qualitative as well as quantitative data, but it can also – as done in this study by working with grounded theory – purely cover qualitative research.
- **Single (intensive case study research):** In order to scrutinize and develop the framework and / or the interactive methodology, intensive case study research of single cases is appropriate. Analysis at this stage should not focus on multiple cases or comparative studies. Single cases − intensively studied − can reveal in greater detail the strengths and weaknesses of the proposed framework and / or approach.
- **Intrinsic / Instrumental:** The situation shall be studied due to intrinsic motivation of the researcher in a specific case and shall further serve as medium to reflect upon usefulness and suitability of the boundary work framework and / or the proposed approach in their current state.
- **Unstructured or groundbreaking cases:** Due to the difficult framework conditions as often encountered in developing countries, such as a fragmented water sector, unclear roles and responsibilities of often competing organisations, lack of data, high fluctuation of staff, and others, cases studies in the developing world can often be considered as either unstructured or groundbreaking. ‘Unstructured’ means that problems are

not well ordered or defined and information is not available in a written or condensed manner. The problem is mostly contested and no 'best solution' is obvious. 'Groundbreaking' implies that little to nothing is known about the current situation and the boundary settings and no structured research has been done on this issue so far.

What to do in the local case? The research for this study has revealed the need to develop true boundary concepts on the problems to be addressed at the research site, the objectives to be achieved and the management principles to be applied. There further exists the need for development of proper functioning boundary objects, in terms of bridging agents, processes, mechanisms and products that are specifically designed to acknowledge and redress poverty, unemployment and the distinct inequalities. Facilitating such a process requires a legitimate bridging agent, who could moderate discussions and decision-making. Considering the local 'clash of concepts' between poverty alleviation and nature conservation, despite the extraordinary efforts, experiences (and struggles) to combine exactly these two elements through the nation's 'Working for Water' programme, a legitimate bridging agent should have a conceptual background in both, socio-economic as well as ecological thinking. Experts in the local context, who have knowledge and (limited) resources to facilitate such a process, have rather been noted as purely focusing on conservation outcomes, and would respectively at this stage not qualify to bridge across the societal divide. Acknowledging the strengths and addressing the weaknesses that characterise the local Catchment Management Forums, research is recommended to analyse, how these existing organisations at micro level can be re-organised and supported to allow to meaningfully contribute to an integrated and holistic water resources management approach.

There was further yet no strongly established *science-policy* relationship at the research site, despite this region being of particular interest for different South African Universities. Potentially, also strengthened relationships between local actors and international organisations could support approaching the outlined challenges. Further, there is the particular need to evolve a stronger *science-society* relationship, especially across the societal gap to previously disadvantaged communities. Developing this relationship would be seen as facilitating targeted knowledge generation, away from a (narrow) conservation driven perspective to a broader sustainability oriented perspective, in order to jointly develop ‘real-life solutions’ to complex socio-ecological ‘real-life challenges’.

Get science to work – developing tailor-made boundary objects: Future research is required to translate and communicate the findings of this study through tailor – made boundary objects based on the core principle that science must be accessible without barriers to everyone (intellectually, legally and technically), also in developmental contexts, and contexts characterised by extreme dichotomies. All boundary objects must thus be barrier–free to the highest extent possible (acknowledging open-access principles, translated into different (local) languages, technically accessibly also for previously disadvantaged communities, and many more) to facilitate all three levels of public participation: information, consultation and active engagement of the broad variety of stakeholders from science, governmental organisations, local interest groups and including the previously disadvantaged communities. The boundary objects thus need to address skills of stakeholders based on very different levels of knowledge and literacy and acknowledging very different settings for ‘access to information’.

6 REFERENCES

Agrawala, S., K. Broad, and D. H. Guston. 2001. Integrating Climate Forecasts and Societal Decision Making: Challenges to an Emergent Boundary Organization. Science, Technology, & Human Values 26: 454–477. Special Issue: Boundary Organizations in Environmental Policy and Science.

Alexander, E. R. 2001. The planner-prince: Interdependence, rationalities and post-communicative practice. Planning Theory and Practice. 2(3): 311−324.

Allan, T. 2006. IWRM: The New Sanctioned Discourse, in Mollinga, P. P., A. Dixit, and K. Athukorala (eds). Integrated Water Resources Management: Global Theory, Emerging Practices and Local Needs. New Delhi. Sage Publications: 38−63 (also published as Occasional Paper 50 SOAS Water Issues Study Group in 2003, SOAS & King's College London, University of London).

Berger, J. O., and D. A. Berry. 1988. Statistical Analysis and the Illusion of Objectivity. American Scientists. 76(2): 159−165.

Boyce, J. K. 1987. Agrarian impasse in Bengal. Institutional constraints to technological change. Oxford University Press.

Braun, D. and D. H. Guston. 2003. Principal-agent theory and research policy: an introduction. Science and Public Policy. 30 (5): 302–308.

Buch, A., and A. B. Dixon. 2009. South Africa's Working for Water Programme: Searching for Win–Win Outcomes for People and the Environment. Sustainable Development. 17. 129–141.

Cash, D. W. 2001. In order to Aid in Diffusing Useful and Practical Information: Agricultural Extension and Boundary Organisations. Science, Technology and Human Values. 26: 431−453. Special Issue: Boundary Organizations in Environmental Policy and Science.

Cash, D. W., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, and J. Jäger. 2002. Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making. John F. Kennedy School of Government, Harvard University. Faculty Research Working Paper Series. RWP02-046.

Cash, D. W., W.C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jäger, and R. B. Mitchell. 2003. Knowledge systems for sustainable development. Proceedings of the National Academy of Science of the United States of America (PNAS). 100 (14).

Charmaz, K. 2006. Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. SAGE.

Checkland, P. 1981. Systems Thinking, Systems Practice. London: John Wiley & Sons.

Cheng, A. S., A. K. Gerlak, L. Dale, and K. Mattor. 2015. Examining the adaptability of collaborative governance associated with publicly managed ecosystems over time: insights from the Front Range Roundtable, Colorado, USA. Ecology and Society 20(1): 35.

Clark, M. J. and J. L. Gardiner. 1994. Strategies for Handling Uncertainty in Integrated River Basin Planning. In: Kirby, C. and W. R. White (eds). 1994. Integrated River Basin Development. John Wiley, Chichester: 437−445.

Clark, W. C. 2007. Sustainability science: A room of its own. PNAS 104(6): 1737−1738.

Clark, W. C., T. P. Tomich, M. van Noordwijk, N. M. Dickson, D. Catacutan, D. Guston, and E. McNie. 2010. Toward a general theory of boundary work: Insights from the CGIAR’s natural resource management programs. CID Working Paper No. 199. Center for International Development. Harvard University. Cambridge, MA: Harvard University.

Coetzer A., and J. Low. 2012. An evaluation of the Contractor Development Model of Working for Water. Water SA. 38 (5): 793−796.

CSIR. 2010. A CSIR perspective on water in South Africa – 2010. CSIR Report No. CSIR/NRE/PW/IR/2011/0012/A ISBN: 978-0-7988-5595-2. Republic of South Africa.

Dehnhardt, A., and U. Petschow. 2008. Sustainability in River Basins. A question of Governance. Munich: oekom.

Department Cooperative Governance and Traditional Affairs and GTZ. 2010a. Having your say. A Handbook for Ward Committees. Pretoria. Republic of South Africa.

Department Cooperative Governance and Traditional Affairs and GTZ. 2010b. Making ward committees function. Ward Committee Resource Book. Best practices & lessons learnt for municipal officials, councillors & local governance practitioners. Pretoria. Republic of South Africa.

Department Housing and CSIR Building and Construction Technology. 2005. Guidelines for Human Settlement Planning and Design. Volume 2. Capture Press, Pretoria. Republic of South Africa.

Department of the Premier. 2009. Report Back on the Investigation into the Water Quality Status of the Berg River and the Eerste River and the Assessment of the Water Shortage Crisis in Knysna and Sedgefield. File: PCF 260209-Water Task Team. Western Cape Government. Republic of South Africa. Unpublished.

Department Public Service and Administration. 2010. Community Development Workers Programme: Progress Report. “Working together to advance the South African developmental state”. 2003–2010. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. n.d.a. Guide to the National Water Act. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. n.d.b. Water Management Institutions Overview. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. c. 1999a. Establishing a Catchment Management Agency. Guide 1 in the CMA/WUA Guide Series. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. c. 1999b. Establishing a Water User Association. Guide 3 in the CMA/WUA Guide Series. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. 2001. Guidelines on the Establishment and Management of Catchment Forums in support of Integrated Water

Resources Management. First Edition. Integrated Water Resources Management Series. Sub-Series No. MS 6.1. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. 2003. Strategic Framework for Water Services. Water is life, sanitation is dignity. Republic of South Africa.

Department Water Affairs and Forestry. 2004a. Knysna Municipality. Water Services Development Plan. Prepared by Stuart Scott International. Republic of South Africa.

Department Water Affairs and Forestry. 2004b. The Working for Water Programme: Annual Report 2002/3. Department of Water Affairs and Forestry. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. 2007a. Project No: 2005-021. Outeniqua Coast Water Situation Study. Republic of South Africa.

Department Water Affairs and Forestry. 2007b. Guidelines for Catchment Management Strategies. Towards equity, sustainability and efficiency. First Edition. Pretoria. Republic of South Africa.

Department Water Affairs and Forestry. c. 2009. Water for Growth & Development Framework. Version 7. Pretoria. Republic of South Africa.

Department Water Affairs. 2010a. Reconciliation Strategy for Knysna. Republic of South Africa.

Department Water Affairs. 2010b. Reconciliation Strategy for Sedgefield. Republic of South Africa.

Department Water Affairs. 2010c. Reconciliation Strategy for Rheenendal. Republic of South Africa.

Department Water Affairs. 2010d. Reconciliation Strategy for Karatara. Republic of South Africa.

Department Water Affairs. 2012a. National Water Resources Strategy. Presentation to the Water Sector Leadership Group on 16 – 17 October 2012. Unpublished.

Department Water Affairs. 2012b. Annual Performance Plan 2012/13–2014/15. Tabling date: 07 March 2012. Republic of South Africa.

Department Water Affairs. 2013. National Water Resource Strategy. Water for an Equitable and Sustainable Future. June 2013. Second Edition. Republic of South Africa.

Dewar, I. 2010. Cracking the Gini Code. And finding bottom-up economics. <http://led.co.za/document/cracking-gini-code-part-i>, viewed 25 May 2015.

Dorcey, A. H. J. 1986. Bargaining in the Governance of the Pacific Coastal Resources: Research and Reform. Vancouver: Westwater Research Centre, The University of British Columbia.

Dörendahl, E. I. 2013. Boundary work and water resources: Towards improved management and research practice?. ZEF Working Paper Series 64. Bonn: ZEF Center for Development Research. <www.zef.de/uploads/tx_zefportal/Publications/wp122.pdf>, viewed 25 May 2015.

Eden District Municipality. 2009. Water Crisis Management Progress Report. 12 February 2009. George. Republic of South Africa.

Eden District Municipality. 2012a. Integrated Development Plan (IDP) 2012/13−2016/17. Final, May 2012 5 Year IDP. George. Republic of South Africa.

Eden District Municipality. 2013. Eden District Municipality Final Draft of the 2013/2014 Reviewed IDP. “Eden, A Future Empowered Through Excellence”. George. Republic of South Africa. <www.edendm.co.za/index.php?option=com_remository&Itemid=6&func=startdown&id=1215>, viewed 25 May 2015

Enge, K. I., and S. Whiteford. 1989. The keepers of water and earth. Mexican rural social organization and irrigation. University of Texas Press, Austin.

ESSA (Environmental and Social Systems Analysis Ltd.). 1982. Review and Evaluation of Adaptive Environmental Assessment and Management, Environment Canada Report. Vancouver: Environment Canada.

Evans, R. 2005. Introduction: Demarcation socialized: Constructing boundaries and recognizing difference. Sci. Technol. Hum. Values 30: 3–16. DOI: 10.1177/0162243904270713.

Gieryn, T. F. 1983. Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. American Sociological Review 48 (6): 781–795. DOI: 10.2307/2095325.

Glaser, B. G., and A. L. Straus. 2009. The Discovery of Grounded Theory: Strategies for Qualitative Research. Transaction Publishers.

Godfrey, L. 2007. Ecosystem Governance and the Trialogue Debate: An Overview of the Trialogue Relationship and the Engagement along Interfaces. In: Turton, A. R., H. J. Hattingh, G. A. Maree, D. J. Roux, M. Claassen, and W.F. Strydom (eds). 2007. Governance as Trialogue: Government-Society-Science in Transition. Berlin, Heidelberg. Springer Verlag.

Grindle, M. 1999: In Quest of the Political: The Political Economy of Development Policy Making. CID Working Paper No. 17. Center for International Development at Harvard University. <www.hks.harvard.edu/centers/cid/publications/faculty-working-papers/cid-working-paper-no.-17>, viewed 26 May 2015

Guston, D. H. 2001. Boundary Organizations in Environmental Policy and Science: An Introduction. Science, Technology and Human Values. 26: 399−408. Special Issue: Boundary Organizations in Environmental Policy and Science.

GWP (Global Water Partnership). 2000. Integrated Water Resources Management. TAC Background Paper No. 4. GWP, Stockholm, Sweden.

Halbert, C. L. 1993. How Adaptive is Adaptive Management? Implementing Adaptive management in Washington State and British Columbia. Reviews in Fisheries Science, 1(3): 261−283.

Hattingh J., M. Claassen, J. Leaner, G. Maree, W. Strydom, A. R. Turton, E. Van Wyk, M. Moolman. 2005. Towards innovative ways to ensure successful implementation of government tools. Report ENV-P-I 2004-083. CSIR. Pretoria. Republic of South Africa.

Hirsch Hadorn, G., H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mnsuy, D. Joye, C. Pohl, U. Wiesmann, and E. Zemp (eds). 2008. Handbook of Transdisciplinary Research. Springer. UK.

Hofwegen, P. J. M. v., and G. W. Jaspers 1999. Analytical Framework for Integrated Water Resource Management: Guidelines for Assessment of Institutional Frameworks. International Institute of Infrastructural, Hydraulic and Environmental Engineering (IHE), Monograph 2, Rotterdam, AA Balkema Publishers.

Holling, C. S. 1978. Adaptive Environmental Assessment and Management. John Wiley and Sons.

Holloway, A., G. Fortune, P. Zweig, L. Barrett, A. Benjamin, V. Chasi, and J. de Waal. 2012. Eden & Central Karoo Drought Disaster 2009 – 2011. "The Scramble for Water". Report. June 2012. Stellenbosch University. Disaster Mitigation for Sustainable Livelihoods Programme. Stellenbosch. Republic of South Africa.

Hoppe, R. 2005. Rethinking the science-policy nexus: from knowledge utilization and science technology studies to types of boundary arrangements. Poiesis Praxis, 3: 199−215.

Hornidge, A. 2011. 'Creative industries': Economic programme and boundary concept. Journal of Southeast Asian Studies. 42: 253−279 DOI: 10.1017/S002246341100004X.

Hornidge, A., L. Oberkircher, A. Kudryavtseva. 2013. Boundary management and the discursive sphere − Negotiating 'realities' in Khorezm, Uzbekistan. Geoforum. 45: 266–274.

Hough, J. A., and H. Prozesky. 2012. Beneficiaries' aspirations to permanent employment within the South African Working for Water Programme. Social Dynamics 38(2): 331−349.

Hough, J. A., and H. Prozesky. 2013. 'I don't want to go back to the farm': A case study of Working for Water beneficiaries. South African Journal of Science. 109(9/10): 1−8.

Huitema, D., and E. Turnhout. 2009. Working at the science-policy interface: a discursive analysis of boundary work at the Netherlands Environmental Assessment Agency. Environmental Politics. 18(4): 675−594.

Hunt, R. C. 1990. 'Organizational control over water: the positive identification of a social constraint of farmer participation'. In: Sampath R. K., and A. R. Young (eds). 1990. Social, economic, and institutional issues in Third World irrigation management. Studies in Water Policy Management, No. 15. Westview Press, Colorado: 141−154.

Huppert, W. 1989. Situation conformity and service orientation in irrigation management. Basic concepts. Sonderpublikation der GTZ No.242. GTZ, Eschborn.

Johnson, B. L. 1999. The Role of Adaptive Management as an Operational Approach for Resource Management Agencies. Ecology and Society. 3(2): 8.

Karar, E. 2000. Catchment Management Fora in Kwazulu-Natal: review of lessons learnt using a SWOT analysis. Presented at WISA 2000, Sun City, South Africa, 28 May – 1 June 2000. Republic of South Africa. www.ewisa.co.za/literature/files/19karar.pdf>, viewed 26 May 2015.

Keating, T. J. 2001. Lessons from Recent History of the Health Effects Institute. Science, Technology and Human Values. 26 (4). Special Issue: Boundary Organizations in Environmental Policy and Science.

Knysna Catchment Management Forum. 2008. Constitution of the Knysna Catchment Management Forum. Unpublished.

Knysna Municipality. 2007. Knysna Bulk Water Supply Planning Study. Executive Summary. Report No: 4303/400941. Prepared by Ninham Shand Consulting Services. Republic of South Africa.

Knysna Municipality. 2008. Spatial Development Framework. "A Path to a Sustainable Future". Republic of South Africa.

Knysna Municipality. 2009a. Comprehensive Integrated Water and Sanitation Business Plan For Greater Knysna. April 2009 – Final. Republic of South Africa.

Knysna Municipality. 2009b. Implementation Plan for Bulk Water Supply Augmentation for Greater Knysna. 2009 – 2014. BIG Application. August 2009. Republic of South Africa.

Knysna Municipality. 2010. Water Services Development Plan. 2011/12. Republic of South Africa.

Knysna Municipality. 2011. Opportunity and Constraints Investigation. Prepared by Pillay M., K. Shippey, and B. Lawson of Aurecon (Pty) Ltd, as part of the Knysna Bulk Water Supply Study. Republic of South Africa.

Knysna Municipality. 2012a. Integrated Development Plan 2012 – 2017. Republic of South Africa.

Knysna Municipality. 2012b. Neighbourhood Development Programme Grant (NDPG). Study Report for Knysna Municipality. Prepared by ARUP. Republic of South Africa.

Knysna Municipality. 2012c. Water Services Development Plan. IDP Cycle 2013−2017. Main Report. Republic of South Africa.

Knysna Municipality. 2013. Integrated Development Plan. 2013−2014. Knysna. Republic of South Africa.

Kuklick, H. 1983. The Sociology of Knowledge − Retrospect and Prospect. Annual Review of Sociology. 9: 287–310. DOI: 10.1146/annurev.so.09.080183.001443.

Lambert, A. 2003. Assessing non revenue water and its components: a practical approach. In: IWA. 2003. Water21. Issue 5.4. Article 2.

Lamont, M., and V. Molnár. 2002. The Study of Boundaries across the Social Sciences. Annual Review of Sociology 28: 167−195. DOI: 10.1146/annurev.soc.28.110601.141107.

Lawrence, R. J., and C. Després. 2004. Futures of Transdisciplinarity. Futures 36: 397−405. <www.sciencedirect.com/science/journal/00163287/36/4>, viewed on 25 May 2015.

Lee, K. N. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Washington D.C.: Island Press.

Leidel, M., N. Hagemann, J. Seegert, C. Weigelt, N. Zakorchevna, and F. Blumensaat. 2014. Supporting decisions in water management by exploring information and capacity gaps: experiences from an IWRM study in the Western Bug River Basin, Ukraine. Environmental Earth Science 72: 4771–4786. DOI: 10.1007/s12665-014-3863-8.

Levine, J. 2004. Adaptive Management in river restoration: theory vs practice in western North America. Water Resources Center Archives, University of California, Multi-Campus Research Unit. http://repositories.cdlib.org/wrca/restoration/levine>, viewed 29 May 2015.

Local Government. 1998. Municipal Structures Act (Act No 117 of 1998). Republic of South Africa.

Local Government. 2000. Municipal Systems Act (Act No 32 of 2000). Republic of South Africa.

Lowdermilk, M. K. 1990. 'Irrigation, water control and anarchy'. In: Sampath, R. K., and R. A. Young (eds). 1990. Social, economic, and institutional issues in Third World irrigation management. Studies in Water Policy and Management, No. 15: 155−174. Westview Press, Colorado.

Magadlela, D., and N. Mdzeke. 2004. 'Social Benefits in the Working for Water programme as a public works initiative'. South Africa Journal of Science. 100: 94−96.

Marcot, B. G. 1998. Selecting Appropriate Statistical Procedures and Asking the Right Questions: A Synthesis. In: Sit, V., and B. Taylor (eds).1998. Statistical Methods for Adaptive Management Studies. Research Branch, Ministry of Forests, Victoria, BC.

Mattor, K., M. Betsill, C. Huayhuaca, H. Huber-Stearns, T. Jedd, F. Sternlieb, P. Bixler, M. Luizza, and A. S. Cheng. Transdisciplinary research on environmental governance: A view from the inside. Environmental Science and Policy. 42: 90−100.

Max-Neef, M. A. 2005. Foundations of transdisciplinarity. Ecological Economics 53: 5–16. DOI: 10.1016/j.ecolecon.2005.01.014

McAllister, M. K., and R. M. Petermann. 1992. Decision Analysis of a Large-scale Fishing Experiment Designed to Test for Genetic Effect of Size-selective Fishing on British Columbia Pink Salmon. Canadian Journal of Fisheries and Aquatic Sciences, 49(7): 1305−1314.

McConnachie, M. M., R. M. Cowling, B. W. van Wilgen, and D. A. McConnachie. 2012. Evaluating the cost-effectiveness of invasive plant removal: a case study from South Africa. Biological Conservation. 155: 128–135.

McConnachie, M. M., R. M. Cowling, C. M. Shackleton, and A. T. Knight. 2013. The Challenges of Alleviating Poverty through Ecological Restoration: Insights from South Africa's "Working for Water" Program. Restoration Ecology. 21 (5): 544–550.

McKenzie, R., and W. A. Wegelin. 2009. Challenges facing the implementation of water demand management initiatives in Gauteng Province. Water SA 35(2) (Special WISA 2008 edition).

McKenzie, R., Z. N. Siqalaba, and W. A. Wegelin. 2012. The State of Non-Revenue Water in South Africa (2012). Report to the Water Research Commission. WRC Report No. TT 522/12. Republic of South Africa.

McLain, R. J., and R. G. Lee. 1996. Adaptive Management. Promises and Pitfalls. Environmental Management. 20(4): 437−448.

Medema, W., and P. J. Jeffrey. 2005. eWater Report Series No. 7 − IWRM and Adaptive Management − Synergy or Conflict? − Deliverable D1.1.1.

Medema, W., B.S. McIntosh, and P. J. Jeffrey. 2008. From Premise to Practice: a Critical Assessment of Integrated Water Resources Management and Adaptive Management Approaches in the Water Sector. Ecology and Society. 13(2): 29.

Millennium Ecosystem Assessment. 2003. Millennium Ecosystem Assessment. Ecosystems and Human Well-Being. A framework for Assessment. Washington, Covelo, London. Island Press. <www.millenniumassessment.org/en/Framework.html>, viewed 26 May 2015.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Miller, C. 2001. Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime. Science, Technology and Human Values. 26 (4). Special Issue: Boundary Organizations in Environmental Policy and Science.

Mollinga, P. P. 2008a. Boundary work – challenges for interdisciplinary research in natural resources management. Habilitationskolloquium 26 November 2008. ZEF, Bonn. Germany. Unpublished.

Mollinga, P. P. 2008b. The rational organisation of Dissent. Boundary concepts, boundary objects and boundary settings in the interdisciplinary study of natural resources management. ZEF Working Paper Series. No 33.

Mollinga, P. P. 2008c. 'Water, Politics and Development: Framing a Political Sociology of Water Resources Management.' Water Alternatives. 1(1): 7−23.

Mollinga, P. P. 2008d. For a Political Sociology of Water Resources Management. ZEF Working Paper Series. No 31. <www.zef.de/uploads/tx_zefportal/Publications/wp31.pdf>, viewed 26 May 2015.

Mollinga, P. P. 2009. Water Policy Dynamics in State-Centric Regimes. Some Preparatory Notes. Presentation at the Conference: Water Policy Dynamics in State-Centric Regimes, ZEF, Bonn, 24.−25.3.2009. Unpublished.

Mollinga, P. P. 2010a. Boundary Work and the Complexity of Natural Resources Management. Crop Science. 50 (1): 1−9.

Mollinga, P. P. 2010b. Boundary concepts for interdisciplinary analysis of irrigation water management in South Asia. ZEF Working Paper Series 64. Bonn: ZEF Center for Development Research. <www.zef.de/uploads/tx_zefportal/Publications/wp64.pdf>, viewed 26 May 2015.

Mollinga, P. P. 2010c. Transdisciplinary Method for Water Pollution and Human Health Research. ZEF Working Paper Series. No. 59.

Mtapuri, O. 2014. The Expanded Public Works Programme: Reflections from South Africa. Mediterranean Journal of Social Sciences. 5(8): 544−551.

Neubert, S., W. Scheumann, A. van Edig, and W. Huppert. 2005. Integriertes Wasserressourcen-Management. Ein Konzept in die Praxis überführen. Baden-Baden: Nomos.

North, D. C. 1990. Institutions, Institutional Change and Economic Performance, Cambridge University Press. Cambridge.

North D. C. 1994. Economic Performance Through Time. The American Economic Review. 84(3): 359−368.

Oberkircher, L., M. Shanafield, B. Ismailova, and L. Saito. 2011. Ecosystem and social construction: an interdisciplinary case study of the Shurkul lake landscape in Khorezm, Uzbekistan. Ecology and Society 16 (4): 20. <http://dx.doi.org/10.5751/ES-04511-160420>, viewed 29 May 2015.

Ohlson, D. W. 1999. Exploring the Application of Adaptive Management and Decision Analysis to Integrated Watershed Management. Vancouver. The University of British Columbia.

Padt, F. 2009. Integrated Water Resources Management in Semi-Authoritarian Regimes: Lip-Service or Real Progress? Learning from the IUCN's Water and Nature Initiative 2001−2008. Presentation at the Conference: Water Policy Dynamics in State-Centric Regimes, ZEF, Bonn, 24.−25.3.2009.

Pahl-Wostl, C., and J. Sendzimir. 2005. The relationship between IWRM and Adaptive Management – Discussion Input for NeWater international Platforms. NeWater Working Paper 3.

Pahl-Wostl, C., P. Kabat, and J. Möltgen (eds). 2007. Adaptive and Integrated Water Management. Coping with Complexity and Uncertainty. Heidelberg: Springer Verlag.

Parma, A. M. and the NCEAS Working Group on Population Management. 1998. What can Adaptive Management Do for Our Fish, Forest, Food, and Biodiversity. Integrative Biology. 1: 16−26.

Paulsen, N., and T. Hernes (eds). 2003. Managing Boundaries in Organizations: Multiple Perspectives. Hampshire and New York. Palgrave Macmillan.

Perring, N., K. Turner, and H. Erwee. c. 2009. Sedgefield water augmentation case study. IMESA Papers.

Petermann, R. M., and M. M'Gonigle. 1992. Statistical Power Analysis and the Precautionary Principle. Marine Pollution Bulletin, 24(5): 231−234.

Plusquellec, H., C. Burt and H. W. Wolter. 1994: Modern water control in irrigation. Concepts, issues, and application. World Bank Technical Paper 246. World Bank, Washington DC.

Pohl, C. 2005. Transdisciplinary collaboration in environmental research. Futures. 37: 1159−1178.

Pohl, C., and G. Hirsch Hadorn. 2007. Principles for Designing Transdisciplinary Research. Munich. Oekom Verlag.

Raadgever, G. T., E. Mostert, N. Kranz, E. Interwies, and J. Timmermann. 2008. Assessing Management Regimes in Transboundary River Basins: Do They Support Adaptive Management? Ecology and Society 13(1): 14.

Republic of South Africa. 1956. Water Act (No 54 of 1956). Republic of South Africa.

Republic of South Africa. 1996. Constitution of the Republic of South Africa (Act 108 of 1996). Republic of South Africa.

Republic of South Africa. 1997a. Water Services Act (Act No 108 of 1997). Republic of South Africa.

Republic of South Africa. 1997b. White Paper on Water Policy. Republic of South Africa.

Republic of South Africa. 1998a. National Water Act (Act No. 36 of 1998). Government Printers. Pretoria. Republic of South Africa.

Republic of South Africa. 1998b. National Environmental Management Act (Act No 107 of 1998). Republic of South Africa.

Republic of South Africa. 2002. Disaster Management Act. (Act No. 57 of 2002) Republic of South Africa.

Republic of South Africa. 2003. National Environmental Management: Protected Areas Act (Act No. 57 of 2003). Republic of South Africa.

Republic of South Africa. 2004. National Environmental Management Amendment Act (Act No 8 of 2004). Republic of South Africa.

Republic of South Africa. 2005. National Disaster Management Framework (General Notice. Notice 654 of 2005. Republic of South Africa.

Republic of South Africa. 2009. National Environmental Management: Protected Areas Act (57/2003): Regulations for the Proper Administration of the

Knysna Protected Environment. Gazette 32797. Regulation 1175. Republic of South Africa.

Ridder, D., E. Mostert, H. A. Wolters (eds). 2005. Learning Together to Manage Together − Improving Participation in Water Management. Osnabrück: University of Osnabrück. Institute of Environmental Systems Research. Osnabrück. Germany.

Rodricks, S. 2010. TEEBCase: Working for Water Programme in South Africa. <www.teebweb.org/wp-content/uploads/2013/01/Working-for-Water-Programme-in-South-Africa.pdf>, viewed 29 May 2015.

Rogers, K. 1998. Managing Science/Management Partnerships: a Challenge of Adaptive Management. Conservation Ecology. 2(2): R1.

Rogers, P. and A. W. Hall. 2003. Effective Water Governance. TEC Background Papers 7. Stockholm. Global Water Partnership.

Rogers, K., and R. Luton. 2011. Strategic Adaptive Management as a Framework for Implementing Integrated Water Resource Management in South Africa. Report to the Water Research Commission. WRC Report No. KV 245/10. Pretoria. Republic of South Africa.

Roux, D. J., P. J. Ashton, J. L. Nel, and H. M. MacCay. 2008. Improving Cross-Sector Policy Integration and Cooperation in Support of Freshwater Conservation. Conservation Biology, 22 (6): 1382−1387.

Roux, D. J., K. Murray, J. L. Nel, L. Hill, H. Roux, and A. Driver. 2011. From scorecard to social learning: a reflective coassessment approach for promoting multiagency cooperation in natural resource management. Ecology and Society 16(1): 24.

Saravanan, V. S., G. McDonald, and P. P. Mollinga. 2008. Critical Review of Integrated Water Resources Management. Moving Beyond Polarised Discourse. ZEF Working Paper Series. No 29. <www.zef.de/uploads/tx_zefportal/Publications/wp29.pdf>, viewed 29 May 2015.

Scholz, R. W., and O. Tietje. 2002. Embedded Case Study Methods. Integrating quantitative and qualitative knowledge. California. Sage Publications.

Schreiner, B., and R. Hassan (eds). 2011. Transforming Water Management in South Africa. Designing and Implementing a New Policy Framework. Springer. DOI: 10.1007/978-90-481-9367-7.

Schreiner, B. 2013. Viewpoint − Why has the South African National Water Act been so difficult to implement? Water Alternatives 6(2): 239−245.

Secretariat of the Convention on Biological Diversity. n.d. Ecosystem Approach Sourcebook. The Ecosystem Approach Advanced User Guide.

Secretariat of the Convention on Biological Diversity. 2004. The Ecosystem Approach, (CBD Guidelines). Montreal. Canada.

Simpungwe, E. 2006. Water Stakeholders and Common Ground. Challenges for Multi-Stakeholder Platforms in Water Resources Management in South Africa. Wageningen University.

South African National Parks. 2006. Coordinated Policy Framework Governing Park Management Plans. Republic of South Africa.

South Africa National Parks. 2007. Annual Report 2006/2007. Pretoria. Republic of South Africa.

South African National Parks. 2010. SANParks's role in commenting on development proposals and land use change applications within the priority natural areas of the Garden Route National Park. Official Communication. Republic of South Africa.

South African National Parks. 2012a. Annual Report 2011/2012. Republic of South Africa.

South African National Parks. 2012b. Garden Route National Park. Park Management Plan. Republic of South Africa.

South African National Parks. 2013a. Annual Report 2012/2013. Republic of South Africa.

South African National Parks. 2013b. Joint Management Actions for Emergency Breaching. Communication between SANParks and Sedgefield Ratepayers and Voters Association. Unpublished.

South African National Parks. 2014a. Annual Report 2013/2014. Republic of South Africa.

South African National Parks. 2014b. Garden Route National Park: State of Knowledge. South African National Parks unpublished report. Republic of South Africa.

Star, S. L., and J. R. Griesemer. 1989. Institutional Ecology,' Translations' and Boundary Objects: Amateurs and Professionals in Berkley's Museum of Vertebrate Zoology, 1907−39. Social Studies of Science (SAGE). 19: 387−420.

Statistics South Africa. 2011. Knysna. <www.statssa.gov.za/?page_id=993&id=knysna-municipality>, viewed 25 May 2014.

Statistics South Africa. 2014. Poverty Trends in South Africa. An examination of absolute poverty between 2006 and 2011. Report No.:03-10-06. Pretoria. Republic of South Africa. <http://beta2.statssa.gov.za/?page_id=1854&PPN=Report-03-10-06> viewed 22 December 2014.

Sternlieb, F., R. P. Bixler, H. Huber-Stearns, C. Huayhuaca. 2013. A question of fit: Reflections on boundaries, organizations and social-ecological systems. Journal of Environmental Management 130: 117−125.

Stone, I. 1984. Canal irrigation in British India. Perspectives on technological change in a peasant economy. Cambridge South Asian Studies No.29. Cambridge. Cambridge University Press.

Taylor, B. S., L. Kremstaer, and R. Ellis. 1997. Adaptive Management of Forests in B.C. Report for the Forest Practice Branch, Strategic Policy Section, British Columbia Ministry of Forests. Victoria: Queen’s Printer.

Turpie, J. K. 2003. The existence value of biodiversity in South Africa: How interest, experience, knowledge, income and perceived level of threat influence local willingness to pay. Ecological Economics 46: 199–216.

Turpie, J. K., B. J. Heydenrych, and S. J. Lamberth. 2003. Economic value of terrestrial and marine biodiversity in the Cape Floristic Region: implications for defining effective and socially optimal conservation strategies. Biological Conservation 112: 233–251.

Turpie J. K., C. Marais, and J. N. Blignaut. 2008. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. Ecological Economics. 65: 788 – 798.

Turton, A. R., H. J. Hattingh, G. A. Maree, D. J. Roux, M. Claassen, and W.F. Strydom (eds). 2007. Governance as Trialogue: Government-Society-Science in Transition. Berlin, Heidelberg. Springer Verlag.

United Nations. 1992. Convention on Biological Diversity.

Urgenson, L. S., H. E. Prozesky, and K. J. Esler 2013. Stakeholder perceptions of an ecosystem services approach to clearing invasive alien plants on private land. Ecology and Society 18(1): 26. <http://dx.doi.org/10.5751/ES-05259-180126>, viewed 29 May 2015.

van Wilgen, B. W., D. C. Le Maitre, and R. M. Cowling. 1998. Ecosystem services, efficiency, sustainability and equity: South Africa's Working for Water programme. Trends in Ecology & Evolution 13: 378.

van Wilgen, B. W., B. Reyers, D. C. Le Maitre, D. M. Richardson, and L. Schonegevel. 2008. A biome-scale assessment of the impact of invasive alien plants on ecosystem services in South Africa. Journal of Environmental Management 89: 336–349.

van Wilgen, B. W. 2009. The evolution of fire and invasive alien plant management practices in fynbos. South African Journal of Science. 105: 335−342.

van Wilgen, B. W., C. Dyer, J. H. Hoffmann, P. Ivey, D. C. Le Maitre, D. M. Richardson, M. Rouget, A. Wannenburgh, and J. R. U. Wilson. 2011a. National-scale strategic approaches for managing introduced plants: insights from Australian acacias in South Africa. Diversity and Distributions 17: 1060–1075.

van Wilgen B. W., A. Khan, and C. Marais. 2011b. Changing Perspectives on Managing Biological Invasions: Insights from South Africa and the Working for Water Programme. In: Richardson, D. M. (ed). 2011. Fifty Years of Invasion Ecology: The Legacy of Charles Elton. 1st edition. Blackwell Publishing Ltd.

van Wilgen, B. W., and D. M. Richardson. 2012 Three centuries of managing introduced conifers in South Africa: Benefits, impacts, changing perceptions and conflict resolution. Journal of Environmental Management 106: 56−68.

van Wilgen, B. W., D. C. Le Maitre, A. Wannenburgh, I. M. Kotze, L. van den Berg, and L. Henderson. 2012a. An assessment of the effectiveness of a large, national-scale invasive alien plant control strategy in South Africa. Biological Conservation. 148: 28–38.

van Wilgen, B. W., R. M. Cowling, C. Marais, K. J. Esler, M. McConnachie, and D. Sharp. 2012b. Challenges in invasive alien plant control in South Africa. South African Journal of Science. 108: 11–12.

Vromans, D. C., K. S. Maree, S. Holness, N. Job, and A. E. Brown. 2010a. The Garden Route Critical Biodiversity Areas Map Book. Garden Route Initiative. South African National Parks. Knysna. Republic of South Africa.

Vromans, D. C., K. S. Maree, S. Holness, N. Job, and A. E. Brown. 2010b. The Garden Route Biodiversity Sector Plan for the George, Knysna and Bitou Municipalities. Supporting land-use planning and decision-making in Critical Biodiversity Areas and Ecological Support Areas for sustainable development. Garden Route Initiative. South African National Parks. Knysna. Republic of South Africa.

Walker, D. A. 1996. An Approach to the Management of Groundwater Pollution. Ph.D. Thesis, Department of Earth and Ocean Sciences, Faculty of Graduate Studies, the University of British Columbia.

Walters, C. J., and R. Hilborn., 1978. Ecological Optimization and Adaptive Management. Annual Review of Ecology and Systematics, 9: 157−188.

Walters C. J., and C. S. Holling. 1990. Large-scale Management Experiments and Learning by Doing. Ecology. 71(6): 2060−2068.

Walters, C. J. 1986. Adaptive Management of Renewable Resources. New York: Macmillan Publishing.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1(2): 1. <www.consecol.org/vol1/iss2/art1/>, viewed 29 May 2015.

Western Cape Government. 2014. Western Cape Government: Overview. Overview of the Western Cape. <https://www.westerncape.gov.za/your_gov/70#premier>, viewed 25 May 2015.

White, D. D., E. A. Corley, and M. S. White. 2008. Water Manager's Perceptions of the Science-Policy Interface in Phoenix, Arizona: Implications for an Emerging Boundary Organization. Society and Natural Resources. 21(2): 230−243.

Wilderness Lakes Catchment Management Forum. 2007. New Constitution of the Wilderness Lakes Sub-Catchment Management Forum (as amended by the Forum on 1 August 2007). Unpublished.

Wilderness Lakes Catchment Management Forum. 2012. Minutes of meeting of 25 January 2012 (Preliminary for Approval). Unpublished.

Wilhite, D. A., and M. H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. Water International 10(3): 111–120.

Wilson J. R. U., P. Ivey, P. Manyama, and I. Nänni. 2013. A new national unit for invasive species detection, assessment and eradication planning. South African Journal of Science. 109(5/6): 1−13.

Woodworth, P. 2007. Working for Water in South Africa: saving the world on single budget? World Policy Journal. 3: 1–43.

WWC. 2000. Final Report: Second World Water Forum and Ministerial Conference, Ministry of Foreign Affairs.

7 APPENDIX

ANNEX 1	Adaptive management principles (Ohlson 1999: 14−15)
ANNEX 2	The generic adaptive management process (Ohlson 1999: 13−14)
ANNEX 3	Adaptive management tools (Ohlson 1999: 15−17)
ANNEX 4	Overview over the framework for assessment of management regimes (Raadgever et al. 2008: 6−8)
ANNEX 5	Twelve principles of the Ecosystem Approach
ANNEX 6	Operational guidance for application of the Ecosystem Approach
ANNEX 7	Twelve tasks to be considered when applying the Ecosystem Approach
ANNEX 8	The analytical approach of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2003: 150−151)
ANNEX 9	Figures illustrating the societal dichotomy at the Study Site

ANNEX 1 Adaptive management principles (Ohlson 1999: 14–15)

Principles and Description:

Continuous and Deliberate Learning: Ecosystems are inherently complex and continually evolving as a result of natural and anthropogenic processes. Uncertainty is the key issue that underlies all major resource and environmental management problems. A formal and structured approach to learning about the functional relationships that drive these evolutionary processes is central to the adaptive management approach (Holling 1978).

Field Science and Formal Experimentation: Adaptive Management is field science. Functional knowledge of ecosystem behaviours can only be developed by carrying out formal experiments that test hypothesis (Dorcey 1986). Adaptive management advocates the use of experimental management techniques for developing and testing hypotheses (Walters and Holling 1990). These hypotheses usually take the form of predictions about how one or more important ecosystem indicators will respond to management interventions.

Systems Approach: Adaptive management is based on a formal application of systems theory, which focuses on i) wholes and their emergent properties, ii) internal and external hierarchical arrangements of wholes, and iii) functional interactions between component parts of wholes (Checkland 1981).

Integration of Management and Research: Adaptive management calls for the integration of management and research into a single activity, with resource managers actively involved in the process of defining problems, generating and testing hypotheses, and evaluating outcomes (Holling 1978, ESSA 1982). An implicit assumption is that information gained in the process of implementation will be used to meet management objectives.

ANNEX 2 The generic adaptive management process (Ohlson 1999: 13–14)

Steps and Description:

Define Problem Boundaries: Most environmental management problems are fraught with uncertainty and complexity. To make them tractable, boundaries of the management problem are clearly defined. Walters (1986) suggests bounding the problem the problem in four dimensions: 1) the breadth of factors considered, 2) the depth of details, 3) the spatial scale, and 4) the time scale and resolution.

Identify Key Uncertainties: Explicitly identify what is unknown about the ecosystem being managed. More specifically, identify which of these unknowns are most important to resolve in order to increase confidence in management interventions and policy directions (Walters 1986).

Chose Ecosystem Indicators: Appropriate ecosystem indicators are established based directly on the key uncertainties that need to be resolved. A commitment to thorough monitoring is made up front, and sufficient resources are allocated. Marcot (1998) identifies that for AM studies an indicator should: 1) respond rapidly to changes, 2) signal changes in other variables of interest, 3) be monitored efficiently, and 4) be causally linked to changes of interest.

Generate Alternate Hypotheses: Alternate hypotheses are generated that centre on the key uncertainties. These hypotheses guide the design of management experiments.

Design Management Experiments: Experiments are designed in conjunction with ongoing management activities. Both qualitative and quantitative aspects of good experiment design are addressed to test alternative hypotheses (Lee 1993).

Implement and Monitor: Managers, researchers and technicians collaborate to meet both management and research goals. Data collection activities focus on previously chosen ecosystem indicators – in most cases these will be consistent with ongoing management data requirement (e.g. water quality measures) (Taylor et al. 1997).

Feedback results: Experimental Results are applied toward the ongoing improvement of management activities. Results are used to improve understanding of ecosystem functioning and to update original hypotheses.

ANNEX 3 Adaptive management tools (Ohlson 1999: 15−17)

Tools and Description:

1. **Modelling:** Adaptive management makes use of all sorts of modelling, including:
   a) Conceptual Modelling: Conceptual models synthesize current understanding of ecosystem functioning or describe hypotheses of ecosystem response to management intervention. They can be presented with a combination of words, symbols or mathematical expressions. (Walker 1996)
   b) Simulation modelling: Simulation models use one or more algorithms to transfer a set of input data into output data. Their use is primarily predictive, helping to test a particular theory or propose a particular management action. Models serve for important functions: i) as a means of organising thought, ii) as a mean of structuring large amount of data, iii) as a tool for comparison and simulations, and iv) as a means of facilitating collaborative problem solving. Adaptive management proponents stress that it is the process of model building rather than the model simulation that are most important in terms of gaining improved overall understanding of resource management situations (Walters 1986).
2. **Interdisciplinary workshops:** In an effective adaptive management process, government resource management professionals, scientists and other stakeholders enter into a partnership to regularly redefine objectives and redirect management actions. A unique interdisciplinary approach to this is fund in the **Adaptive Environmental Assessment and Management (AEAM) Workshop** process developed by the early practitioners of adaptive management (Holling 1978). These workshops have three general goals: i) to include all stakeholder interests, ii) to work across jurisdictional boundaries, and iii) to bound conflict.
3. **Experimental Design:** Adaptive management requires large scale experimentation at the scale of ecosystems. Effective experimental management requires rigorous attention to the details of experimental design (McAllister and Petermann 1992). Specific considerations include:

a) The Fundamentals: Well designed experiments are often structured around the use of **controls** (against which to compare one or more experimental treatments).

b) Statistical Power Analysis: Classical approaches to experimental design focus on the avoidance of Type I and Type II errors. Statistical power analysis is a well established body of classical statistics theory that is sued to design experimental and monitoring programs or evaluate their results (Peterman and M'Gonigle 1992). The 'statistical power' of an experiment is simply a measure of the probability of correctly accepting as true an hypothesis that is true; that is, it I an inverse measure of the chance of making Type II error. Calculating the statistical power as part of a formal adaptive management program enables researchers and managers to judge how much confidence to place in their monitoring results. Further, statistical power analysis can be used to design new experiments, monitoring systems and data analysis programs that have a higher chance of delivering valid results, and even to rank alternative designs.

c) Bayesian Statistics: Bayesian statistical analysis is an approach that has been developed for cases where a lack of existing data sets or a lack of controls and replicates occurs. The approach allows experimenters to assess impacts by assessing a **prior probability** that a hypothesis is correct (based on expert opinion), and then uses data collected during experimentation to update the assigned probability (Berger and Berry 1988). Although the task is computationally intensive, it allows experimental management to proceed in a structured manner.

d) Qualitative Tests of Validity: The validity of experimental results can also be tested for validity by qualitative means. Internal threats to validity are those that led to questions of whether something else really caused the observed effect in an experiment. Examples include **Hawthorne effects** where the act of experimentation itself actually caused the effect, and **maturation effects** where the effect would have occurred anyway as a result of forces already in effect. External threats to validity are those that question whether the experimental result can be applied to other circumstances. Examples here include **cumulative effects** where it is difficult to determine which of several simultaneous interventions actually caused the effect, and **complexity effects** where it is difficult to even identify the relationships between cause and effect. Understanding the possible qualitative threats is vital to the experimental management design process (Lee 1993)**.**

ANNEX 4 Overview over the framework for assessment of management regimes (Raadgever et al. 2008: 6–8)

CRITERIA	INDICATORS
A. Actor networks	
1. Cross-sectoral co-operation	• Sectoral governments actively involve other government sectors • Cooperation structures include government bodies from different sectors; many contacts generally • Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed
2. Cooperation between administrative levels	• Lower-level governments are involved in decision making by higher-level governments • Cooperation structures include government bodies from different hierarchical levels; many contacts generally • Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed
3. Cooperation across administrative boundaries	• Downstream governments are involved in decision making by upstream governments • International/ transboundary cooperation structures exist (e.g., river basin commissions); many contacts generally • Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed

4. Broad stakeholder participation	• Legal provisions concerning access to information, participation in decision making (e.g., consultation requirements) and access to courts • Cooperation structures include non-governmental stakeholders • Non-governmental stakeholders actually contribute to agenda setting, analyzing problems, developing solutions, and taking decisions ("co-production") • Non-governmental stakeholders undertake parts of river basin management themselves, e.g., through water users' associations • Governments take stakeholder input seriously
B. Legal framework	
5. Appropriate legal framework	• A complete and clear legal framework for water management exists (with sufficient detail) • Policies have to be reviewed and changed periodically
6. Adaptable legislation	• Laws and regulations can easily be changed • Water (use) rights can easily be changed / are not permanent
C. Policy	
7. Long time horizon	• Solutions for short-term problems do not cause more problems in the (far) future (20 years or more) • Preparations are already being made for the (far) future (20 years or more)
8. Flexible measures, keeping options open	• Measures taken now or proposed for the near future do not limit the range of possible measures that can be taken in the far future and are preferably reversible

9. Experimentation	• Small-scale policy experiments take place / are financially supported
10. Full considera-tion of possible measures	• Several alternatives and scenarios are discussed • Alternatives include small- and large-scale and structural and non-structural measures
11. Actual imple-mentation of policies	• Plans and policies are actually implemented • Policies are not dogmatically stuck to when there are good reasons not to implement them, e.g., new and unforeseen circumstances and new in-sights
D. Information management	
12. Joint or partici-pative information production	• Different government bodies are involved in set-ting the terms of reference and supervising the search, or are at least consulted (interviews, sur-veys etc.) • The same for non-governmental stakeholders
13. Interdisciplinari-ty	• Different disciplines are involved in defining and executing the research: in addition to technical and engineering sciences, also, e.g., ecology and the social sciences
14. Elicitation of mental models / crit-ical self-reflection about assumptions	• Researchers allow their research to be chal-lenged by stakeholders and present their own assumptions in as far as they are aware of them • Research results are not presented in an authori-tative way, but in a facilitative way, to stimulate reflection by stakeholders about what is possible and what it is they want
15. Explicit consid-eration of uncertain-ty	• Uncertainties are not glossed over, but commu-nicated (in final reports, orally)

16. Broad communication	• Governments exchange information and data with other governments • Governments actively disseminate information and data to the public: on the internet, and also by producing leaflets, through the media, etc.
17. Use of information	• New information is used in public debates (and is not distorted) • New information influences policy

As to the issues for which information should be produced, communicated, and used, see under C.

E. Financing

18. Appropriate financing system	• Sufficient (public and private) resources are available • Costs are recovered from the users by public and private financial instruments (charges, prices, insurance, etc.) • Decision making and financing under the same control • Authorities can take loans and depreciate their assets to facilitate efficient use of resources and replacement of assets

ANNEX 5 Twelve principles of the Ecosystem Approach

Principle 1: The objectives of management of land, water and living resources are a matter of societal choices.

Different sectors of society view ecosystems in terms of their own economic, cultural and society needs. Indigenous peoples and other local communities living on the land are important stakeholders and their rights and interests should be recognized. Both cultural and biological diversity are central components of the ecosystem approach, and management should take this into account. Societal choices should be expressed as clearly as possible. Ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans, in a fair and equitable way.

Principle 2: Management should be decentralized to the lowest appropriate level.

Decentralized systems may lead to greater efficiency, effectiveness and equity. Management should involve all stakeholders and balance local interests with the wider public interest. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation, and use of local knowledge.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Management interventions in ecosystems often have unknown or unpredictable effects on other ecosystems; therefore, possible impacts need careful consideration and analysis. This may require new arrangements or ways of organization for institutions involved in decision-making to make, if necessary, appropriate compromises.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

a) Reduce those market distortions that adversely affect biological diversity;
b) Align incentives to promote biodiversity conservation and sustainable use;

c) Internalize costs and benefits in the given ecosystem to the extent feasible.

The greatest threat to biological diversity lies in its replacement by alternative systems of land use. This often arises through market distortions, which undervalue natural systems and populations and provide perverse incentives and subsidies to favour the conversion of land to less diverse systems.

Often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs (e.g. pollution) escape responsibility. Alignment of incentives allows those who control the resource to benefit and ensures that those who generate environmental costs will pay.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Ecosystem functioning and resilience depends on a dynamic relationship within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment. The conservation and, where appropriate, restoration of these interactions and processes is of greater significance for the long-term maintenance of biological diversity than simply protection of species.

Principle 6: Ecosystem must be managed within the limits of their functioning.

In considering the likelihood or ease of attaining the management objectives, attention should be given to the environmental conditions that limit natural productivity, ecosystem structure, functioning and diversity. The limits to ecosystem functioning may be affected to different degrees by temporary, unpredictable of artificially maintained conditions and, accordingly, management should be appropriately cautious.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Connectivity between areas should be promoted where necessary. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Ecosystem processes are characterized by varying temporal scales and lag-effects. This inherently conflicts with the tendency of humans to favour short-term gains and immediate benefits over future ones.

Principle 9: Management must recognize the change is inevitable.

Ecosystems change, including species composition and population abundance. Hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertainties and potential "surprises" in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Biological diversity is critical both for its intrinsic value and because of the key role it plays in providing the ecosystem and other services upon which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected. There is a need for a shift to more flexible situations, where conservation and use are seen in context and the full range of measures is applied in a continuum from strictly protected to human-made ecosystems

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Information from all sources is critical to arriving at effective ecosystem management strategies. A much better knowledge of ecosystem functions and the impact of human use is desirable. All relevant information from any concerned area should be shared with all stakeholders and actors, taking into account, inter alia, any decision to be taken under Article 8(j) of the Convention on Biological Diversity. Assumptions behind proposed management decisions should be made explicit and checked against available knowledge and views of stakeholders.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Most problems of biological-diversity management are complex, with many interactions, side-effects and implications, and therefore should involve the necessary expertise and stakeholders at the local, national, regional and international level, as appropriate.

<www.cbd.int/ecosystem/principles.shtml> viewed 26 May 2015.

ANNEX 6 Operational guidance for application of the Ecosystem Approach

1. Focus on the relationships and processes within ecosystem.

The many components of biodiversity control the stores and flows of energy, water and nutrients within ecosystems, and provide resistance to major perturbations. A much better knowledge of ecosystem functions and structure, and the roles of the components of biological diversity in ecosystems, is required, especially to understand:

a. ecosystem resilience and the effects to biodiversity loss (species and genetic levels) and habitat fragmentation; and
b. underlying causes of biodiversity loss; and
c. determinants of local biological diversity in management decisions.

Functional biodiversity in ecosystems provides many goods and services of economic and social importance. While there is a need to accelerate efforts to gain new knowledge about functional biodiversity, ecosystem management has to be carried out even in the absence of such knowledge. The ecosystem approach can facilitate practical management by ecosystem managers (whether local communities or national policy makers).

2. Enhance benefit-sharing.

Benefits that flow from the array of functions provided by biological diversity at the ecosystem level provide the basis of human environmental security and sustainability. The ecosystem approach seeks that the benefits derived from these functions are maintained or restored. In particular, these functions should benefit the stakeholders responsible for their production and management. This requires, inter alia: capacity building, especially at the level of local communities managing biological diversity in ecosystems; the proper valuation of ecosystem goods and services; the removal of perverse incentives that devalue ecosystem goods and services; and, consistent with the provisions of the Convention on Biological Diversity, where appropriate, their replacement with local incentives for good management practices.

3. Use adaptive management practices.

Ecosystem processes and functions are complex and variable. Their level of uncertainty is increased by the interaction with social constructs, which need to be better understood. Therefore, ecosystem management must involve a learning process, which helps to adapt methodologies and practices to the ways in which these systems are being managed and monitored. Implementation programmes should be designed to adjust to the unexpected, rather than to act on the basis of a belief in certainties. Ecosystem management needs to recognize the diversity of social and cultural factors affecting natural-resource use. Similarly, there is a need for flexibility in policy-making and implementation. Long-term, inflexible decisions are likely to be inadequate or even destructive. Ecosystem management should be envisaged as a long-term experiment that builds on its results as it progresses. This "learning-by-doing" will also serve as an important source of information to gain knowledge of how best to monitor the results of management and evaluate whether established goals are being attained. In this respect, it would be desirable to establish or strengthen capacities of Parties for monitoring.

4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to lowest level, as appropriate.

As noted in the description of the ecosystem approach, an ecosystem is a functioning unit that can operate at any scale, depending upon the problem or issue being addressed. This understanding should define the appropriate level for management decisions and actions. Often, this approach will imply decentralization to the level of local communities. Effective decentralization requires proper empowerment, which implies that the stakeholder both has the opportunity to assume responsibility and the capacity to carry out the appropriate action, and needs to be supported by enabling policy and legislative frameworks. Where common property resources are involved, the most appropriate scale for management decisions and actions would necessarily be large enough to encompass the effects of practices by all relevant stakeholders. Appropriate institutions would be required for such decision-making and, where necessary, for conflict resolution. Some problems and issues may require action at still higher levels, through, for example, transboundary cooperation, or even cooperation at global levels.

5. Ensure intersectoral cooperation.

As the primary framework of action to be taken under the Convention, the ecosystem approach should be fully taken into account in developing and reviewing national biodiversity strategies and action plans. There is also a need to integrate the ecosystem approach into agriculture, fisheries, forestry and other production systems that have an effect on biodiversity. Management of natural resources, according to the ecosystem approach, calls for increased intersectoral communication and cooperation at a range of levels (government ministries, management agencies, etc.). This might be promoted through, for example, the formation of inter-ministerial bodies within the Government or the creation of networks for sharing information and experience.

<www.cbd.int/ecosystem/operational.shtml>, viewed 26 May 2015

ANNEX 7 Twelve tasks to be considered when applying the Ecosystem Approach

Task 1: Involving all members of society in decisions associated with the management of land, water and living resources

Task 2: Ensuring management is decentralised to the lowest appropriate level

Task 3: Ensuring the effects of management actions (potential or actual) on adjacent and other ecosystems are taken into account

Task 4: Ensuring the economic context can be understood

Task 5: Identifying measures to conserve ecosystem structure and functioning so as to maintain ecosystem services

Task 6: Considering what measures can be taken to ensure ecosystems are managed within the limits of their functioning

Task 7: Identifying actions to address problem(s) at the appropriate temporal and spatial scales

Task 8: Taking varying temporal scales and lag-effects into account when considering the sustainable use of ecosystems

Task 9: Using adaptive management to address the problem(s) identified

Task 10: Seeking an appropriate balance between, and integration of, conservation and use of biological diversity

Task 11: Ensuring all forms of relevant knowledge including, scientific, indigenous and local knowledge, innovations and practices are included

Task 12: Facilitating the involvement of all stakeholders including all sectors of society and scientific disciplines

The Ecosystem Approach Advanced User Guide: www.cbd.int/ecosystem/sourcebook/advanced-guide/?steps, viewed 26 May 2015

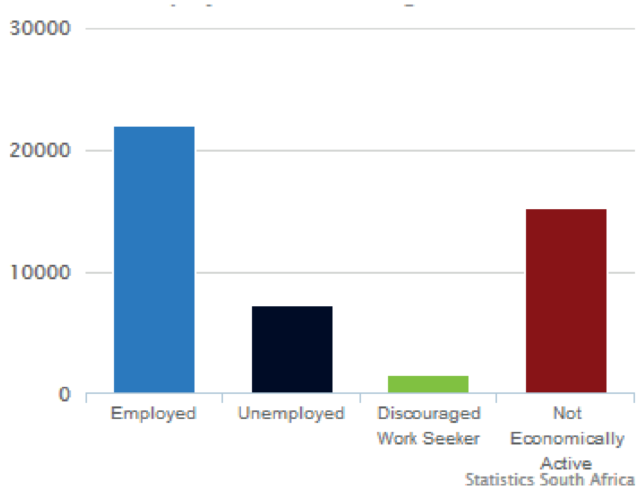
ANNEX 8 The analytical approach of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2003: 150−151)

1) **Identify and categorize ecosystems and their attendant services.** To facilitate the assessment of complex ecosystems, the MA will classify them into a limited number of categories as a basis for assessing the services they provide. Ecosystem services are identified and grouped into **functional** categories: provisioning, regulating, cultural, and supporting.
2) **Identify links between services and human societies.** Here the links are described between human societies and the particular ecosystem services that they use or benefit from. This includes defining the components of human well-being that are affected by the services (such as health, livelihood, culture, and equity), as well as the human activities that in turn affect ecosystems and the supply of services (such as population growth, consumption, and governance).
3) **Identify indirect and direct drivers.** In this task a list of indirect and direct drivers of the state of ecosystems and their services is drafted. Indirect and direct drivers affect not only ecosystems and their services but also each other. For example, demographic changes (an indirect driver) can affect ecosystems though land use change (a direct driver) but also can influence other indirect drivers such as social values and institutions.
4) **Select indicators of ecosystem conditions, services, human well-being, and drivers.** A set of indicators is selected to assess the state of ecosystems, ecosystem services, human well-being, and drivers. As an example, if the ecosystem service is food provision, then a potential indicator for the ecosystem state would be area under cultivation; for the service, quantity of food produced; for human well-being, rates of malnutrition; and for drivers, population growth. Next, these indicators are quantified or otherwise evaluated for use in the other analytical tasks.
5) **Assess historical trends and the current state of ecosystems and their services and drivers.** The current state of ecosystems and their services is assessed by assembling and analyzing data on the indicators selected. The details of how these data will be analyzed have not been completely worked out, but some considerations are discussed in Chapter 2. Since

ecosystems are dynamic, an important issue to be addressed is the meaning of “current conditions.” In some cases this will refer to the most recent data collected, but for most ecosystems it must take into account year-to-year and perhaps inter-decadal variability. (For example, it is not useful to refer to the availability of fresh water for a particular year because of its strong year-to-year variability.)

6) **Evaluate impact on human well-being.** This is among the most challenging tasks in the MA, since it involves the translation of information largely from the natural sciences (such as the state of fresh water, soil, and forests) into variables of concern to society (health, livelihoods, wealth, and security, for instance). One challenge is that a given service can affect several components of human well-being. Another challenge lies in sorting out the many possible trade-offs among services. Finally, the distribution of service benefits among societal groups will need careful consideration.
7) **Develop scenarios.** The MA is concerned not only with the historical, present, and short-term future trends of ecosystems, but also with future trends over the medium and longer term. This information is needed to anticipate critical changes in ecosystems and to develop response strategies. The aim of this task is to identify a set of plausible futures or “scenarios” for ecosystems, services, and drivers.
8) **Evaluate possible responses.** In this task the many possible “response options” are identified for preventing the deterioration of ecosystem services or recovering lost services. This includes evaluating the success of past response options and developing guiding principles for designing needed policies. Consistency is needed between the response strategies identified here and those used in the scenarios.
9) **Analyze and communicate uncertainty.** Since the MA is concerned with a new and rapidly changing body of knowledge, it is clear that many of the findings will be uncertain. Assessing and communicating the level of certainty in a clear and consistent manner is therefore a central task of the MA.

ANNEX 9 Figures illustrating the societal dichotomy at the Study Site



Employment Status	Number
Employed	21 939
Unemployed	7 248
Discouraged Work Seeker	1 589
Not Economically Active	15 146

Figure 16 Employment for those aged 15–64 within Knysna Municipality (Statistics South Africa 2011)

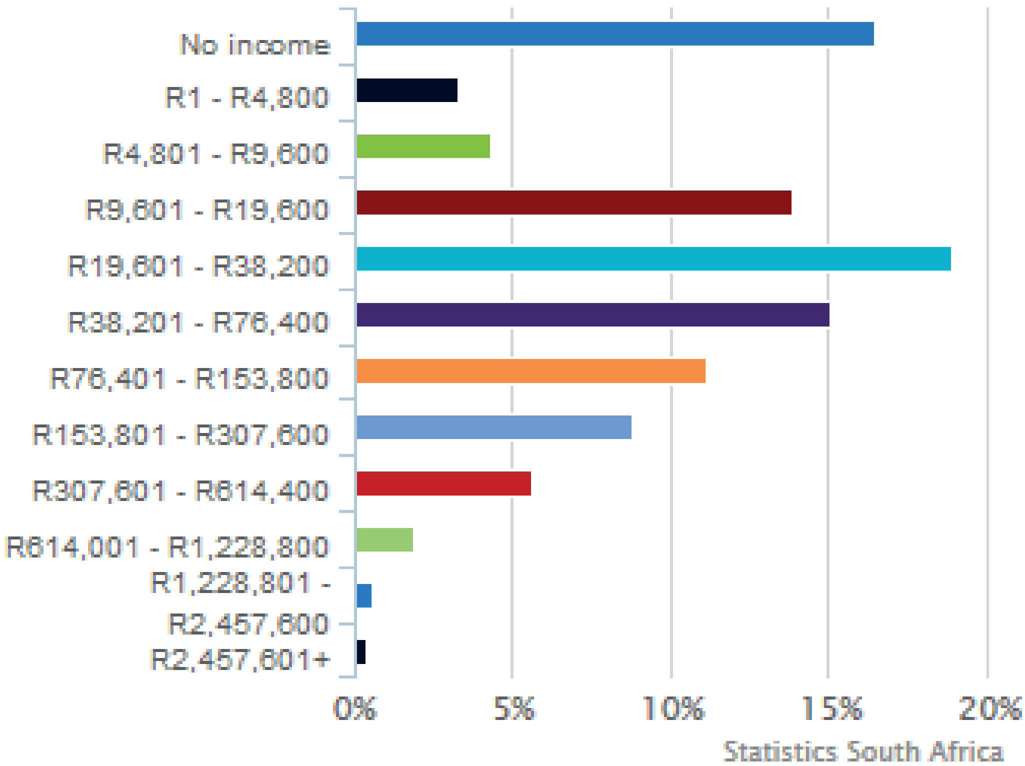
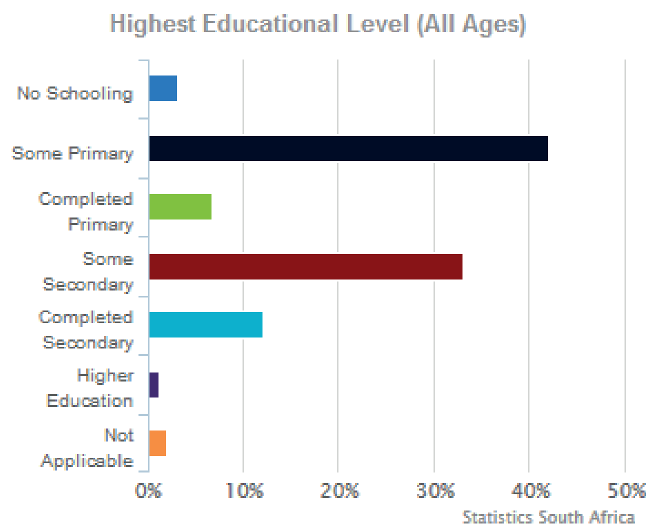


Figure 17 Average household income within Knysna Municipality (Statistics South Africa 2011)

Table 18 Crimes reported at the Knysna (Western Cape) police precinct (Knysna Municipality 2013: 42 following South African Police Service (SAPS) 2012)

Crime Category		**2010**	**2011**	**2012**
Contact Crime	Murder	28	24	26
	Total sexual crimes	132	139	205
Property related crime	Burglary at residential premises	861	843	917
	Burglary at non-residential premises	149	120	123
Crime heavily dependent on police action for detection	Drug related crime	857	793	856
	Driving under the influence of alcohol or drugs	445	418	445
	Total	**2472**	**2337**	**2572**



Group	**Percentage**
No Schooling	3,1
Some Primary	41,9
Completed Primary	6,7
Some Secondary	33
Completed Secondary	12,1
Higher Education	1,3
Not Applicable	2

Figure 18 Highest educational level for Knysna Municipality (all ages) (Statistics South Africa 2011)

Boundary Work for Collaborative Water Resources Management

Esther Irene Dörendahl

Water is a basis for life and ecosystem health. And water, especially in regions affected by water scarcity, is a highly contested and politicised natural resource. The state-of-the-art in sustainable water resources management requires collaborative approaches that foster the integration of conflicting interests of multiple stakeholders. Achieving integration in complex and contested real life situations however remains a major challenge. Boundary work can facilitate this ambitious goal. This study evolves boundary work science to improve collaboration in the water sector. It develops a framework for boundary work that enables understanding, structuring and approaching barriers for collaborative water resources management. A case study from the Garden Route region, South Africa gives a grounded basis for the conceptual developments and further provides in-depth insights into reasons and obstacles for collaborative water resources management in a contested local case. The case study serves both: An intrinsic analysis of a conflictive case, and conceptual developments to the boundary work framework – tested against local realities.

ISBN 978-3-8405-0131-9
EUR 20,20
02020
9 783840 501319