Key Interventions to Improve Local Groundwater Governance

Report to the
WATER RESEARCH COMMISSION

by

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PREAMBLE

'The institutional framework for water management shall as far as possible be simple, pragmatic and understandable. It shall be self-driven and minimise the necessity for State intervention. Administrative decisions shall be subject to appeal'.

(Principle 22, White Paper on a National Water Policy for South Africa (Department of Water Affairs, 1997)

PREPENDUM: Water User Associations

While this investigation was underway a notice was issued (Department of Water Affairs, 2013) regarding a National Water Policy Review with the stated aim of 'improved access to water, equity and sustainability.' Part of the process of 'improved access' was the proposed abolition of local access via Water User Associations (WUAs). This investigation has retained the terminology of WUA because it is a commonly used global and generic term for the local level of groundwater governance. The governance implications of the Policy Review will be discussed subsequently in the report.

EXECUTIVE SUMMARY

Objectives

There is a growing perception (Seward, 2010; Levy and Xu, 2012) that groundwater governance is simply not working, especially at the local scale, in South Africa. This perception is increasingly being supported by research. Pietersen et al. (2011) assessed local groundwater governance as weak to non-existent in 4 case studies, while Knüppe (2011) summarized groundwater governance in South Africa as 'weak and hardly realised.'

The purpose of this investigation is therefore to address these weaknesses in governance by identifying and prioritizing key interventions that can improve local groundwater governance in South Africa. These interventions should not simply be a wish list, but must be practical and implementable.

At the outset of this project, it was assumed that a conventional study structure could be followed whereby a hypothesis would be identified and tested. However, as data was collected and the literature review progressed, it became evident that such an approach was not possible because of limited empirical evidence. Therefore, an exploratory approach was adopted. An exploratory approach formulates hypotheses while an empirical approach tests them.

Practitioner-Based Enquiry

McIntrye (2006) argues that without the perspective of an insider or practitioner the stock of knowledge on any subject remains incomplete. This investigation provides that perspective. The practitioner is the principal author who worked for DWA from 1978 to 1983 and from 1986 to 2013 as a hydrogeologist. The bulk of the practitioner's work involved providing groundwater inputs to groundwater, surface water, ecosystem and land use governance processes. It was apparent to the practitioner that good hydrogeological science alone was not sufficient to ensure good governance.

Groundwater versus surface water governance

This report focuses on groundwater. Surface water is rarely mentioned. The rationale for this approach is the scale being used. A typical scale for local groundwater governance is a few tens of square kilometres. This scale is several orders of magnitude lower than that of CMAs as currently envisioned in South Africa.

At this scale of governance, surface water issues are – or can be treated – as just another input to the groundwater governance process, along with land use, ecosystem use, equitable use, CMA policies, national policies and so on. Thus, while the integral nature of the hydrological cycle is acknowledged, this report treats groundwater-surface interactions as no more, and no less, important than all the other factors that groundwater must interact with.

Definition of groundwater governance

There is much debate in the academic literature on what governance in general and

groundwater governance in particular mean. For the purpose of this investigation the definition of Moench et al. (2012) was used since it appeared to be the most consistent with the general academic consensus on governance. Groundwater governance (Moench et al., 2012) is:

"The process through which groundwater- related decisions are taken (whether on the basis of formal management decisions, action within markets, or through informal social relations) and power over groundwater is exercised."

A definition of 'good' groundwater governance was chosen on similar grounds (Moench et al., 2012):

"A 'good' groundwater governance environment is one where governance processes equitably reflect the voices and interests of stakeholders (including regional and global stakeholders with interests in resource sustainability) and where broadly supported courses of action can be implemented in an effective and equitable manner."

Governance versus Management

According to Jonker et al. (2010) water governance is the process of making decisions about water resources and water management is the process of implementing those decisions. This investigation supports Jonker's definition but with the caveat that water management is a *part* of governance and not a separate activity. Governance and management are not different *scales* of action, but different *processes*. Both governance and management processes can take place together at local, regional, national or global scales.

Literature Review

An extensive literature review was carried out with the aim of searching for good groundwater governance practices and groundwater governance research methodologies. It was found that:

- Attempts by higher levels of government to unilaterally implement direct management of groundwater will almost certainly fail.
- There are no general panaceas for good groundwater governance: Public, Private and Common Pool governance does not, of itself, predicate governance success. While it would appear that local stakeholder participation is a prerequisite for good local groundwater governance, it is not a guarantee. And while there may be isolated instances of good local governance evolving without the support of an external agency, healthy support from an external agency / higher institution does seem to greatly improve the prospects for good local groundwater governance.
- There are also no specific panaceas, no blueprints that will ensure effective local groundwater governance. A specific tool, for example 'education and awareness programmes', may be associated with good groundwater governance in some cases, be absent in other cases, and be present in some cases where groundwater governance is described as ineffective.
- There are, however, general guidelines that may be of value in identifying which specific details need to be attended to improve local groundwater governance in a specific setting. The details will however be unique for that setting. The general

guidelines include the Ostrom Design Principles (ODP), the World Bank's 20 benchmarking criteria, and the governance 'pillars' or foundations provided by Custodio and Llamas (2003). Only the ODP have been extensively tested empirically and evaluated in academic literature.

Methodology

Several methodologies were investigated, all of which had limitations because either: (a) they were not specific to groundwater, and/or (b) they were untested empirically and/or (c) while being academically and conceptually sound they did not help identify key interventions with the detail required by this project. The compromise methodology adopted by this project was to seek out key interventions to improve local groundwater governance using a backcasting approach combined with the ODP.

Three local case studies were selected:

- **Phillipi Horticultural Area** (governance needed but not in place) – data were collected and analyzed by University of the Western Cape Honours student Zodidi Mgxekwa as part of this project.
- **Northern Sandveld WUA** (WUA in place) – data were obtained from (1) PhD thesis by Kathrin Knüppe (2012), University of Osnabrück, Germany, and (2) principal author's DWA experience.
- **Hermanus Monitoring Committees** (non-WUA governance institution in place) – data were collected and analyzed by University of the Western Cape Honours student Mandilakhe Msutu as part of this project.

Initially 20 possible interventions were identified. These were further analysed by prioritising and grouping to identify 4 key interventions.

Results

(1) **POSSIBLE** INTERVENTIONS

Initially the following interventions were obtained. The list reflects the order in which the interventions were obtained during the project, not their priority. Thus no priority should be attached to the order of the list. The interventions vary in their scale and their detail. Grouping and prioritising was addressed when the *possible* interventions were analyzed so as to determine *key* interventions.

1) Obtain consensus on a definition of good groundwater governance.
2) A paradigm shift in the scientific rules used for groundwater allocations is needed. Current rules based on average annual recharge cannot be substantiated by sound science.
3) Create institutional policies that allow for, encourage and empower WUAs to make their own water management rules.
4) Create institutional policies that allow for, encourage and empower WUAs to monitor their groundwater use.
5) Create institutional policies that allow for, encourage and empower WUAs to monitor the status of their groundwater resource.

6) Create institutional policies that allow for, encourage and empower WUAs to impose graduated sanctions.

7) Create institutional policies that allow for, encourage and empower WUAs to resolve conflicts using rapid, low-cost approaches.

8) Amend the NWA so that WUAs have the right to do water management, instead of it being a privilege that they may or may not be granted.

9) Institutional policies to ensure that WUAs integrate broader societal aims and do not just focus on consumptive use.

10) Include a commitment to the Ostrom Design Principles in the GWS.

11) Foster, encourage and the support of local groundwater governance via polycentric governance and nested enterprises.

12) Develop hydrogeological science methodologies that are robust to spatial and temporal variations under local conditions, and are broadly accepted by all participating stakeholders.

13) Research into the value of $r = 1.5(Tt/S)^{0.5}$ and other simple indicators for predicting spatial impacts with sufficient accuracy.

14) [Philippi] Social entrepreneur to motivate benefits of PHA doing their own monitoring.

15) [Philippi] Hydrogeologists from academic and state institutions to motivate benefits of PHA doing their own monitoring and to provide support where necessary.

16) [Northern Sandveld] Hydrogeologists co-opted to WUA.

17) [Northern Sandveld] DWA information and monitoring data shared with WUA.

18) [Hermanus Monitoring Committees] Expand the role of Monitoring Committees so that they monitor ALL groundwater use in a coherent groundwater domain, rather than just one user in an incoherent domain.

19) Cost-benefit studies to identify where regulation of groundwater use is justified, and where regulation is not justified.

20) Tackle groundwater governance 'Hot Spots' by supporting the implementation of whichever missing Ostrom Design Principle seems the most feasible and most beneficial to implement.

(2) **KEY** INTERVENTIONS

The key interventions recommended by this investigation are given in the table below:

KEY INTERVENTION	RESPONSIBILITY
A 'one-step-at-a-time' approach whereby in a given local setting attention is given to the implementation of one Ostrom Design Principle at a time. The design principle selected should be the one that would be most beneficial to the local stakeholders and the most feasible for the external agency to assist with	DWA and/or WRC and/or Tertiary Education Institutions and/or National Groundwater Governance Association
Initiatives to improve local groundwater governance should take cognizance of, and be guided by, the need to improve social capital at all levels	National Groundwater Governance Association
Initiatives to improve local groundwater governance in South Africa should be driven by an agency/organisation outside of DWA. This agency could be the WRC, a university, or an NGO	'Charismatic' and/or motivated individual
Include a commitment to the Ostrom Design Principles in the GWS	DWA groundwater components

Polycentric local groundwater governance in practice

Polycentric simply means having many centres. While the polycentric governance landscape in its entirety might look very complicated, at the local groundwater governance level it simply means the local governance institution is the governance 'centre' for that particular resource. The WUA, or other applicable institution, might be constituted as follows:

- local consumptive and non-consumptive users of the resource.
- representatives from adjacent water resources-groundwater or surface water – that might interact with the resource in question.
- representatives from higher water institutions such as CMAs to ensure that national and CMA water polices involving equity, sustainability, etc. are adhered to.
- representatives from other local, regional and national institutions that might have concerns about how the resource is used.

This list is not meant to be exhaustive or prescriptive but just to provide some introductory thoughts on how a groundwater WUA might be constituted. The closest existing structures that resemble this polycentric approach are not CMAs or WUAs but groundwater Monitoring Committees, such as the Saldanha Monitoring Committee (Du Plessis, 2009).

Concluding Remarks

In order for local groundwater governance to improve, there needs to be a shift from the perception that groundwater governance can be 'fixed' by a once-off intervention, to the understanding that it is an ongoing and organic process.

The proposed interventions require a change of attitude to local groundwater governance, or a change of mental and conceptual models of local groundwater governance, more than they require changes to laws, science and institutions.

One of the key conceptual underpinnings to good groundwater governance appears to be social capital.

Regarding the current drive to abolish WUAs in South Africa, it is suggested that the key question is what is the best way to improve the net social capital in the overall governance system – local, CMA, national. It is suggested that a move to polycentric governance might increase social capital more effectively than abolishing WUAs.

The requirements and commitment needed to realise good groundwater governance are daunting. There is a very strong case for only attempting to improve local groundwater governance when there is a very strong need to do so, and essentially treating the remainder of the country's groundwater as a *de facto* private good.

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ACRONYMS

BOCMA – Breede Overberg Catchment Management Agency (currently Breede-Gouritz Catchment Management Agency)
CAS – Complex Adaptive System
CMA – Catchment Management Agency
CPR – Common Pool Resource(s)
DWA – Department of Water Affairs (*)
FA – Framework for Action
FAO – Food and Agriculture Organization of the United Nations
GEF – Global Environment Facility
GLWUA – Groot Letaba Water User Association
GWaES – Groundwater Associated Ecosystem Services
GWS – Groundwater Strategy
GWUA – Groundwater User Association IAD – Institutional Analysis and Design IFR – In-stream Flow Requirements
IWRM – Integrated Water Resource Management
KNP – Kruger National Park
MTF – Management and Transition Framework
NASA – National Aeronautics and Space Administration
NGO – Non-governmental Organization
NWA – National Water Act
NWPR – National Water Policy Review
NWRIA – National Water Resources Infrastructure Agency
ODP – Ostrom Design Principles
RSA – Republic of South Africa
SAGGCS – South African Groundwater Governance Case Study
SES – Social Ecological Systems
UNDP – United Nations Development Programme
UNESCO – United Nations Educational, Scientific and Cultural Organization
WPNWP – White Paper on a National Water Policy for South Africa
WRC – Water Research Commission
WRUA – Water Resource User Association
WUA – Water User Association

(*) While this project was underway the Department of Water Affairs (DWA) changed its name to Department of Water and Sanitation. Name changing is not an infrequent activity of the Department, and has included the name of Department of Water Affairs and Forestry for several years. To facilitate finding references to its documents, the name Department of Water Affairs is retained in this report.

1 INTRODUCTION

1.1 Objectives

The overall purpose of this investigation is to identify and prioritize key interventions that can improve local groundwater governance in South Africa. These interventions should not simply be a wish list. They should be practical and implementable.

The impetus for this investigation came from a desire to find good groundwater governance interventions to address the poor groundwater governance situation in South Africa (Seward 2010; Pietersen et al., 2011). Globally, poor groundwater governance is the norm rather than the exception (Wester et al., 2011). The isolated examples of good groundwater governance are explained in terms of quite specific rules that are difficult to transplant to other socio-economic settings (Mukherji and Shah, 2005; Foster et al., 2010; Kulkarni, 2011). Therefore there are no simple, readily available recipes for good groundwater governance that can be imported to South Africa, and therefore a comprehensive investigation is required.

Compared with research into the physical processes of hydrogeology, groundwater governance is highly under-researched both locally and internationally. Addressing this knowledge gap is the key aim of this research.

1.2 Background

South Africa's water legislation has been described as ‘progressive’, ‘advanced’, ‘forward-looking’ and even ‘revolutionary’ (Postel and Richter, 2003; Burns et al., 2006; Funke et al., 2007). The country’s National Water Act (Republic of South Africa (RSA) 1998) contains a host of sophisticated tools, such as the Reserve, Resource Quality Objectives, Licensing, and Water Users Associations for enabling the good governance of groundwater. Yet there is a growing perception (Seward, 2010; Levy and Xu, 2012) that groundwater governance is simply not working, especially at the local scale. This is despite (or possibly because of) all the sophisticated tools available. A local groundwater expert has described the implementation of the National Water Act (NWA) groundwater licensing process (Coetsee, 2010) as a ‘nagmerrie’ (nightmare). The inability to implement these tools could be the result of poor management by DWA, or a lack of human capacity to implement these tools, or that the tools are intrinsically too complex to practically implement.

The perception that groundwater governance is not working at the local scale in South Africa is being increasingly supported by research. Pietersen et al. (2011) described the preponderance of weak or non-existent local governance provisions in four South African case studies. Since groundwater is essentially a local scale phenomenon in South Africa, it is what is happening at the local scale that matters.

The characterization of groundwater governance in South Africa as weak, or non-existent is corroborated by Knüppe (2011) in an extensive survey of expert opinion and other data sources which revealed that South Africa's groundwater governance regime was unable to ensure effective and sustainable resource allocation and

regulation, and that implementation of the NWA (RSA, 1998) was 'weak and hardly realised'.

South Africa's NWA (RSA, 1998) transformed groundwater from private to public property. Consumptive use of groundwater can be authorized via four mechanisms:

- Existing lawful use – i.e. use taking place before the proclamation of the NWA.
- 'Schedule 1 use' – use for purposes such as stock watering and individual properties that is assumed to be so small scale that it does not be regulated.
- 'Generally Authorized' use – typically greater than schedule 1 use, but deemed by hydrogeologists to be sufficiently within the capacity of the resource not to require active controlling.
- 'Licensed' use – use close to, or possibly exceeding the capacity of the resource, and thereby deemed to need controlling.

Since it is the licensed use that most visibly and most consistently requires attention, it is in the licensing process that problems can be most clearly seen. The principal author's experience as an employee of the Department of Water Affairs (DWA) is of inordinate delays in the licensing process. Delays of 10 years or more are not unknown. Very few licenses were ever issued. The principal author's recollection is of only two groundwater licenses being issued in 14 years within the half of the Western Cape that the author worked in. In the few cases where licenses were issued, the licensing conditions were never enforced.

Parsons (2009) painted a similar picture and provided a detailed analysis of nine license applications that he had submitted to DWA on behalf of his clients. None of these applications had yet been approved, although some had been waiting for more than two years. Three of the applications had been 'resolved' since DWA decided a license was not needed, but it took DWA on average 27 months to reach such a conclusion. Parsons (2009) ascertained that only three groundwater licenses had been issued in the Western Cape Province in the last decade. Some 100 000 boreholes are drilled every year in South Africa (Parsons, 2006). However, many of these boreholes were drilled in the Western Cape Region and it seems unlikely that only three of them required licensing. Such inertia is clearly not promoting sustainable, equitable, or efficient use of groundwater. It is more likely that this inertia is contributing to illegal use as groundwater appropriators increasingly perceive that DWA is unable to license groundwater use, and is unable to control illegal groundwater use.

If there was any doubt that progressive water laws do not automatically lead to good water governance, then the South African experience should dispel such doubts. There is clearly a need for a change of approach to groundwater governance in South Africa. Parsons (2009) places responsibility for poor groundwater governance on the lack of capacity at the DWA. Spain does not appear to have the (alleged) dearth of human capacity that South Africa has, and yet it is making similarly slow progress with exercises such as licensing, and validation and verification of existing use (López-Gunn and Cortina, 2006). Some states in India scarcely have any institutions for dealing with groundwater governance, yet isolated examples of good groundwater governance can be found (Van Steenbergen, 2006). Therefore, there is

a need to examine groundwater governance in a broader context than just institutional and human capacity.

1.3 Groundwater versus surface water governance and the scale factor

This investigation focuses on local groundwater governance. A typical scale for this would be a few tens of square kilometres. This scale would be determined by local aquifer boundaries, or by a compartment of a regional aquifer that could sensibly be managed locally. This scale is several orders of magnitude lower than that of CMAs as currently envisioned in South Africa.

At this scale of governance, surface water issues are – or can be treated – as just another input to the groundwater governance process, along with land use, ecosystem use, equitable use, CMA policies, national policies and so on. Thus, while the integral nature of the hydrological cycle is acknowledged, this report treats groundwater-surface interactions as no more, and no less, important than all the other factors that groundwater must interact with.

1.4 Overall Research Approach: Practitioner Based Enquiry

This project revolves around a practitioner-based enquiry (McIntyre, 2006). McIntrye (2006) argues that without the perspective of an insider or practitioner the stock of knowledge on any subject remains incomplete. This investigation provides that perspective. The practitioner is the principal author who worked for DWA from 1978 to 1983 and from 1986 to 2013 as a hydrogeologist. The bulk of the practitioner's work involved providing groundwater inputs to groundwater, surface water, ecosystem and land use governance processes. A major motivation for this investigation was the practitioner's frustration with the ineffective governance processes and the realisation that good hydrogeological science alone was not sufficient to ensure good governance.

The enquiry seeks to provide a better understanding of what is necessary for good groundwater governance to be realised rather than simply provide rules regarding what should and what should not be done. The enquiry is not simply a review of groundwater governance in other countries, a quest for a methodology, and a testing of that methodology using cases studies. The enquiry also contains practitioner reflections on all of these issues. It is accepted that these reflections are necessarily subjective. However, it is hoped that these reflections will help increase thought, debate and wisdom regarding groundwater governance, and not just knowledge.

The exploration of the issues and the practitioner's reflections are presented as a narrative or 'story.' Brophy (2009) and others have discussed the value of the narrative-based approach in detail.

2 DEFINING GROUNDWATER GOVERNANCE

2.1 The Quest for a Definition

In order to assess groundwater governance, a working definition of groundwater governance is needed. Before homing in on groundwater governance, more general concepts of governance will first be discussed, so as to obtain a broader appreciation and perspective of what groundwater governance entails. An oft-cited definition of governance is that of the UNDP (1997):

"The exercise of political, economic and administrative authority in the management of a nation's affairs at all levels — and thus comprises the mechanisms, processes and institutions through which the citizens of the nation articulate their interests, mediate their differences and fulfill their legal rights and obligations."

Wijnen et al. (2012) provide a more general definition:

"The operation of rules, instruments and organizations that can align stakeholder behavior and actual outcomes with policy objectives."

These two definitions suggest that governance is a process, as stated by Lautze et al. (2011), a process with a certain amount of 'fuzziness' as suggested by Varady et al. (2012) which permits a degree of flexibility in what 'good governance' would or would not approve, as pointed out by Doornbos (2003). Put simply, the definitions of governance do not specify the interests or objectives of society, but allows the process of governance to articulate these.

Varady et al. (2012) have taken the definition provided by Saunier and Meganck (2007) in their 'Dictionary and Introduction to Global Environmental Governance' and adapted it to provide their working definition of groundwater governance as:

"The process by which groundwater is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law. It is the art of coordinating administrative actions and decision making between and among different jurisdictional levels – one of which may be global."

This definition reiterates that governance, including groundwater governance, is a ***process*** and gives an indication of the wide range of institutions that may be involved, as well as the wide range of scales. However, Moench et al. (2012) argue that the Varady et al. (2012) definition of governance does not fully capture the wide variety of direct and indirect economic, social and political instruments that may determine governance outcomes. For example governance may, theoretically, be implemented by controlling how an aquifer is used. But agricultural subsidies that encourage or discourage a certain type of land use, and by implication encourage or discourage groundwater abstraction, are also an instrument of groundwater governance, albeit indirectly. To address their concerns, Moench et al. (2012) provide the following definition of groundwater governance:

"The process through which groundwater related decisions are taken (whether on the basis of formal management decisions, action within markets, or through informal social relations) and power over groundwater is exercised."

Moench et al. (2012) add to their definition of the groundwater governance process, by providing the context for 'good' groundwater governance:

"A 'good' groundwater governance environment is one where governance processes equitably reflect the voices and interests of stakeholders (including regional and global stakeholders with interests in resource sustainability) and where broadly supported courses of action can be implemented in an effective and equitable manner."

The key ingredients of good groundwater governance would thus appear to be that it must be 'equitable' and it must be 'effective'. In other words the decisions taken must fairly and equitably reflect the inputs from diverse sectors of society, and the decisions implemented should lead to the broad aspirations of society being effectively met.

It would appear that 'sustainability' in Moench et al.'s (2012) definition is more of an input or concern (presumably from regional and national government technocrats) that must be given fair and equitable consideration, rather than an output that must be rigidly implemented. It is instructive to compare the context of Moench et al.'s (2010) use of 'sustainability' with Foster et al.'s (2010) use of 'sustainable' in their definition of groundwater governance:

"…is focused on the exercise of appropriate authority and the promotion of responsible collective action to ensure sustainable development and efficient utilization of groundwater resources for the benefit of humankind and dependent ecosystems."

In the Foster et al. (2010) definition of groundwater governance, 'sustainable development' appears to be treated as an outcome that must be realized rather than an input to be equitably integrated. While the difference might seem so subtle as to be mere semantics or 'nit-picking', a lot hinges on this seemingly minor difference of interpretation: In the Foster et al. (2010) definition, technocrats would presumably decide on what is 'sustainable' and expect groundwater users to somehow implement and comply with their decision. While most technocrats might agree with this approach, and believe this is how things should be, 'good governance' as outlined by Moench et al. (2012) implies that technocrats provide an input to the process rather than control the process.

It is therefore argued that definitions of groundwater governance should avoid specifying outcomes like 'sustainability', no matter how noble and 'right' these outcomes might seem. These goals may not be what society necessarily wants even if they are enshrined in the nation's Water Act. It is further argued that goals like sustainability represent the water technocrats' hijacking of the governance process, by imposing their viewset on the governance process before it has even begun.

Lautze et al. (2011) tacitly support this point of view by arguing that deciding on outcomes in advance by including them in the definition of governance is like 'putting the cart before the horse'. Good governance, according to Lautze et al. (2011), is supposed to be a participatory process in which all stakeholders help to formulate the desired outcomes. Lautze et al. (2011) analysed numerous definitions of governance to show that:

1) Governance is consistently viewed as the process involved in decision-making.
2) The process of governance takes place through institutions.
3) The processes and institutions of governance involve multiple actors.
4) Governance is not the outcomes of that decision-making.

The following definitions for groundwater governance and good groundwater were adapted from the definitions provided by Lautze et al. (2011) simply by replacing 'water' with 'groundwater'.

"Groundwater governance consists of the processes and institutions by which decisions that affect groundwater are made. Groundwater governance does not include practical, technical and routine management functions such as modeling, forecasting, constructing infrastructure and staffing. Groundwater governance does not include groundwater resources outcomes."

"Good groundwater governance qualities can be proposed as: openness and transparency; broad participation; rule of law (predictability); and ethics, including integrity (control of corruption)."

We now appear to have three approaches to outcomes in definitions of groundwater governance:

1) Outcomes are not specified (Lautze et al., 2011).
2) Outcomes are not specified in the governance definition but are formulated in the governance process (Moench et al., 2012).
3) Outcomes are specified in the definition of groundwater governance (Foster et al., 2010).

This report will use the Moench et al.'s (2012) approach to outcomes in groundwater governance for its working model, since this appears to be more consistent with broader aims and definitions of governance in general.

It is accepted that good groundwater governance qualities must be open, transparent, participative, predictable and ethical as per the definition adapted from Lautze et al. (2011). But more than this, good groundwater governance must be effective (Moench et al., 2012).

If the water technocrats genuinely want to engender participatory governance, they must accept that noble aims like sustainability are, at most, no more than their inputs to the participatory process, and must accept that the participatory decision-making process might end up with some or all of these ideals excluded from, or at least severely revised in the desired outcomes.

2.2 Governance versus Management

This report has selected Moench et al.'s (2012) definition of groundwater governance for its working model:

"The process through which groundwater related decisions are taken (whether on the basis of formal management decisions, action within markets, or through informal social relations) and power over groundwater is exercised."

An understanding of how groundwater management relates to groundwater governance would be helpful. According to the GEF (2012): *'**groundwater management is the set of actions to implement decisions that derive from the process of governance.**'* Jonker et al. (2010) make a similar distinction for water in general when they argue that governance is about *determining* rules, and management is about *implementing* those rules.

In other words groundwater governance is the process of making decisions and groundwater management is about implementing those decisions. Thus governance and management are not separate *scales* of action, but different *processes*. Both processes can take place together at local, regional, national or global scales.

The question now needs to be addressed regarding whether governance and management are separate but complimentary activities, or whether one process is included in the other. Reverting to the definition of Moench et al. (2012), it can be seen that the definition includes both the process of taking decisions *and* implementing them ('***power over groundwater is exercised***'). It is suggested that this is not a mere semantic issue, but of practical importance. Governance cannot take place in a vacuum. Monitoring information is needed to base decisions on. Decisions need to be implemented otherwise governance is no more than a 'talk-shop'. Therefore, this report takes the position that groundwater management is part of groundwater governance, and that groundwater governance is a broader concept than groundwater management.

2.3 Concluding Remarks

Although this report takes a certain viewpoint on the definition of groundwater governance, and follows the approach and definitions proposed by Moench et al. (2012), it is perhaps imprudent to be too restrictive, prescriptive or dogmatic regarding the meaning of groundwater governance, especially given that governance in general is such a holistic and fuzzy concept. The more relaxed, pragmatic definition of Mukherji and Shah (2005) provides some perspective on the matter, where groundwater governance is essentially defined as an inclusive process that takes into account the concerns of scientists, policy makers and the users themselves, as opposed to the more restrictive concept of groundwater management that involves scientists determining rules about groundwater availability and water managers implementing those rules.

Put very simply: groundwater governance involves a lot more than groundwater management. The following textbox gives a summary of what was learnt in the quest for a working definition of groundwater governance:

Simplified definition of groundwater governance:

- The process of making rules related to groundwater.
- The process of implementing those rules.
- The process of enforcing those rules.

Characteristics of groundwater governance:

- Those rules are not restricted to a particular level – they can be made at any level or combinations of levels: global, national, regional, local or individual.
- Those rules are not the exclusive domain of any particular organisation or policy instrument. Groundwater governance can happen without a Water Act, without a national Water Department, without hydrogeologists, and without hydrological monitoring. These are not requirements for groundwater governance.
- Groundwater governance does not require that the groundwater be used sustainably. Moench et al. (2012) give examples of how farming communities in India use groundwater unsustainably to acquire sufficient wealth so that their children can be sufficiently educated that they do not have to return to farm life. Issar (2008) has presented a similar argument – using African examples – in his 'progressing development' approach. Large parts of the Great Plains aquifer would not be used viably if it were used sustainably because in many parts recharge is either too low or non-existent. Similar arguments have been made for Australian aquifers.

Text Box 1. Key lessons regarding groundwater governance definitions

From these attempts to pin down a definition of groundwater governance, it is already possible to identify a tension between different agents:

- Regional, national and global 'hydrocrats' who are concerned about groundwater over use and pollution, want to make rules to stop this and expect local users to either comply with or even implement these rules.

Versus:

- Individual groundwater users who are concerned about getting their fair share of the resource and/or being able to use that resource for economic gain.

3 LITERATURE REVIEW

3.1 Approach used in the literature review

A cursory examination of the literature on groundwater governance suggests that the scientific community is uncertain of what is needed to improve groundwater governance. Therefore the rules for good governance prescribed by the World Bank's 'GW-MATE' initiatives seem somewhat dogmatic. (Foster et al., 2010). For example, Mukherji and Shah (2005) maintain that for every example of an asserted 'pre-requisite' for good groundwater governance, there are hundreds of examples where this 'pre-requisite' has failed to improve groundwater governance, and vice versa. It is usually possible to find an example of good groundwater governance that has arisen without some, or many, of the 'pre-requisites'. One such example is the communities in Yemen that are practicing good groundwater governance without 'pre-requisites' like hydrogeological maps and often even without the help of a hydrogeologist (Taher et al., 2012).

It is therefore far from clear what needs to be done to make groundwater governance work at the local scale. Therefore, given that the implementation of groundwater governance and the study of groundwater governance are still in their infancy, the methodology used in this report was essentially an open-ended, informal and exploratory literature review in an attempt to:

- Better understand the issues behind groundwater governance problems in South Africa and further afield.
- Better understand the building blocks of good groundwater governance.
- Identify methodologies that can potentially be used to better understand groundwater governance issues.
- Identify methodologies that might be useful in the design of good groundwater governance systems.

Specific attention was given to the findings of the World Bank Groundwater Governance Study and the UNESCO Africa Regional groundwater governance workshop. These were scrutinized, summarized and compared with recent academic research and thinking on the topic and related fields, in an attempt to gain a consensus on what groundwater governance is, what good groundwater governance comprises, and what benchmarking criteria, and/or indicators are needed to evaluate groundwater governance.

3.2 Review of: National Water Policy Review (DWA, 2013)

3.2.1 OBJECTIVES

Attempts to improve groundwater governance obviously cannot take place in a vacuum, and will be constrained by the existing institutional landscape. The purpose of introducing the National Water Policy Review (NWPR) at the beginning of the literature review is to provide a cursory overview of that institutional landscape so as better understand the general constraints and opportunities facing groundwater

governance in South Africa. The NWPR applies to all water matters in South Africa and not just groundwater.

3.2.2 REVIEW

The purpose of the National Water Policy Review (NWPR) is to address gaps and oversights from previous policies so that these can be addressed in subsequent legislation. Policies that are not mentioned are deemed not to require attention. The reviewing of past policies so as to guide future legislation is highly problematic since it conflates legislation and policy. Not every piece of water policy in South Africa can be linked to legislation and vice versa. For example, not all the policies in the White Paper on a National Water Policy for South Africa (WPNWP) (DWA, 1997) were adopted in the National Water Act (NWA), and the NWA contains some legislation that is not directly derived from the White Paper.

It is not clear whether the authors of the NWPR are concerned with innovative policies in the WPNWP that were not adopted by the NWA but should have been, or whether there are good laws in the NWA that have no WPNWP 'mandate,' or both, or neither of these scenarios. How the mind-wrenching complexity of policies that were adopted, or weren't adopted, or weren't created, or were created prior to an Act, or were created subsequent to an Act can be sensibly analyzed so as to shape future legislation is beyond comprehension. It would have seemed more sensible to consider gaps and oversights from the NWA rather than a mish-mash of policies.

One area that the NWPR deals with is institutions. The authors of the NWPR argue that WUAs should be abolished and incorporated into CMAs or Regional Water Utilities for the following reasons:

1) Some WUAs *'have assumed a regulatory role'* and are transferring water entitlements within the WUA, which *'is not the intention of localised and collective water user management'*.
2) '*The existing tension between small localised Irrigation Boards owning infrastructure versus the broader intention of a WUA aimed at supporting the decentralisation of water management is creating a confusion of roles*.'
3) '*...there are a number of challenges posed by WUAs in water resource management.*'
4) '*...oversight of a large number of WUAs is becoming a challenge for the Department.*'

The general thinking behind this abolitionist route appears to be that CMAs offer some form of panacea since the NWPR makes much reference is made to Principle 22 of the White Paper:

'Responsibility for the development, apportionment and management of available water resources shall, where possible and appropriate, be delegated to a catchment or regional level in such a manner as to enable interested parties to participate.'

However it can be argued that the authors of the NWPR are being selective even when it comes to which part of this principle they focus on. They are clearly focusing on the CMA mandate section. However attention also needs to be paid to the last part of the principle, namely:

'...in such a manner as to enable interested parties to participate.'

To improve groundwater governance at the *local* level requires attention at the *local* level. Local stakeholders that are concerned about groundwater use at a local level, meaning a few km^2 or a few 10's of km^2 are hardly likely to see a huge CMA covering 1000's of km^2 as the level that would '***enable interested parties to participate***'. Thus it is argued that WUAs should remain because they are the appropriate level that would enable interested and affected parties in a Common Pool groundwater Resource to participate in the governance of that resource.

The specific objections of the NWPR to WUAs will now be discussed:

5) **Some WUAs have assumed a regulatory role.** This, surely, is not a problem since the whole purpose of decentralization is to make decisions at the lowest level possible. WUAs doing regulatory work also take some of the manifest burden off DWA and the CMAs to do this work.

6) **Confusion of roles between Irrigation Boards and WUAs**. This seems a very confused argument because Irrigation Boards are supposed to have transformed to WUAs. If that had happened, some WUAs may have differing roles than others, but it is difficult to see why that should confuse the WUAs concerned. Presumably it is causing confusing to higher level technocrats writing the NWPR, but this hardly seems grounds for abolition. A more nuanced response would be to clarify whatever roles are unclear.

7) **Challenges posed by WUAs**. It is impossible to discuss this since the challenges are not specified. However, without knowing the gravity of the challenges, it is suggested that addressing the challenges might be a more productive route than abolishing WUAs.

8) Oversight of WUAs is becoming a challenge for the Department. As an ex-Departmental practitioner with experience of the Department's challenges, it could be argued that virtually *every* activity it is involved in is a challenge for the Department. Yet the standard response to a challenge is normally to tackle it rather than purge the challenge.

To aid the Department address this challenge the following WPNWP principle is invoked:

Principle 22:

The institutional framework for water management shall as far as possible be simple, pragmatic and understandable. It shall be self-driven and minimise the necessity for State intervention. Administrative decisions shall be subject to appeal.

Thus WUAs that are simple, pragmatic, understandable, and self-driven, should be *minimising the necessity for State intervention.* It is suggested that the real problem for the Department is an inability to accept that it should be minimizing its interventions in WUAs and developing strategies to ensure that WUAs can do their job with minimal intervention.

Two CMAs have been created in the 17 or so years since the 1998 NWA. A further seven are planned. This is a total of nine, a reduction from the original 19. Much social capital has been lost in the process (Jonker et al., 2010). It is thus difficult to be

optimistic that CMAs that can absorb WUAs will exist in the near future, and that the absorption will increase social capital at the local level.

3.2.3 CONCLUDING REMARKS

Thus, in summary, it is argued that: (a) the NWPR has failed to put forward a satisfactory case for the abolition of WUAs, (b) failed to understand the need for stakeholder participation at the lowest possible level so as to ensure equity and sustainability, (c) failed to appreciate what the lowest level is, and (d) failed to appreciate the operational benefits to DWA of a polycentric approach to governance.

Similar findings were presented by Jonker et al. (2010) for the water sector as a whole, and not just groundwater:

'If decisions in a deeply riven and highly unequal society such as South Africa are to move the country towards justice, fairness and sustainability in access to water, governance must extend as far down the stakeholder chain of authority as possible.'

(current authors' underlining)

Putting this in a broader perspective: if the NWPR is representative of broader national institutional attitudes, it suggests there is little or no support for, or trust in, devolving governance to the local level. Thus any attempts to improve local groundwater governance are more likely to be resisted than supported by DWA.

3.3 Review of South African Groundwater Governance Case Study (Pietersen et al., 2011)

3.3.1 OBJECTIVES

The aim of this review is to obtain a broader insight regarding groundwater governance issues in South Africa, and to introduce the debate on how to categorize groundwater governance and how to design improvements.

3.3.2 OVERVIEW

The methodology used in the South African Groundwater Governance Case study is pivotal to selecting a methodology for this project. Therefore the methodology, results, and underlying assumptions are discussed in some detail so that this project can be better informed on selecting an appropriate methodology and case study area(s).

The South African Groundwater Governance Case Study (SAGGCS) report is 'intended to encourage thought and discussion'. The SAGGCS forms part of the World Bank economic and sector analysis ***"Too Big to Fail: The paradox of groundwater governance."*** It is not known why the term 'paradox' is used, since this quotation is often used, but the original source has not been found. Presumably a parallel is being drawn with the banking system where banks are too big/important to be allowed to fail in times of a banking crisis?

The overall aims of the World Bank's groundwater governance economic and sector analysis are:

"Understand the impediments to better governance of groundwater, and to identify the opportunities for ensuring that groundwater forms a key element of integrated water resources management (IWRM) in developing countries; and

Explore the opportunities for using groundwater to help developing countries adapt to climate change."

The SAGGCS comprises an analysis of national strategies to strengthen groundwater governance, and an analysis of the actual implementation of groundwater governance at the local, institutional level. Groundwater governance status at the local level was assessed using a prioritised list (Table 1) of 20 benchmarking criteria (Foster et al., 2010).

Table 1. Check List of 20 benchmarking criteria (Foster et al., 2010)

TYPE OF PROVISION/ CAPACITY	CHECK LIST *in each instance the criteria should be individually ranked in relation to considerations of 'existing provisions' and 'institutional capacity to implement'*		
	No.	CRITERION	CONTEXT
Technical	1	Existence of Basic Hydrogeological Maps	for identification of groundwater resources
	2	Groundwater Body/Aquifer Delineation	with classification of typology
	3	Groundwater Piezometric Monitoring Network	to establish resource status
	4	Groundwater Pollution Hazard Assessment	for identifying quality degradation risks
	5	Availability of Aquifer Numerical 'Management Models'	at least preliminary for strategic critical aquifers
	6	Groundwater Quality Monitoring Network	to detect groundwater pollution
Legal & Institutional	7	Waterwell Drilling Permits & Groundwater Use Rights	for large users, with interests of small users noted
	8	Instrument to Reduce Groundwater Abstraction	waterwell closure/constraint in critical areas
	9	Instrument to Prevent Waterwell Construction	in overexploited or polluted areas
	10	Sanction for Illegal Waterwell Operation	penalizing excessive pumping above permit
	11	Groundwater Abstraction & Use Charging	'resource charge' on larger users
	12	Land-Use Control on Potentially-Polluting Activities	prohibition or restriction since groundwater hazard
	13	Levies on Generation/Discharge of Potential Pollutants	providing incentive for pollution prevention
	14	Government Agency as 'Groundwater Resource Guardian'	empowered to act on cross-sectoral basis
	15	Community Aquifer Management Organisations	mobilizing and formalizing community participation
Cross-Sector Policy Coordination	16	Coordination with Agricultural Development	ensuring 'real water saving' and pollution control
	17	Groundwater-Based Urban/Industrial Planning	to conserve and protect groundwater resources
	18	Compensation for Groundwater Protection	related to constraints on land-use activities
Operational	19	Public Participation in Groundwater Management	effective in control of exploitation and pollution
	20	Existence of Groundwater Management Action Plan	with measures and instruments agreed

The SAGGCS concluded that:

- At the national level technical, legal, institutional and operational governance provisions are reasonable, but cross-sector policy coordination is weak, and the institutional capacity to implement these provisions is generally weak.
- At the local level most of the governance provisions are weak or non-existent, and the institutional capacity to implement these provisions are also generally weak to non-existent.

The SAGGCS recommended that groundwater governance be strengthened via:

1) Integrating the Groundwater Strategy, the National Water Resource Strategy and Catchment Management Strategies.

2) Strengthening the groundwater regulatory environment.
3) Strengthening the institutional capacity of the Department of Water Affairs (DWA), Catchment Management Agencies, and Water Users Associations.
4) DWA to develop a strategy to augment national groundwater human resource capacity.

3.3.3 GENERAL DISCUSSION

The SAGGCS provides a thorough and comprehensive account of the institutional landscape in South Africa as it pertains to groundwater governance matters. Recounting how groundwater was treated as private good in apartheid South Africa provides historical perspective and how the National Water Act (RSA, 1998) transformed groundwater into public property. Nearly all the groundwater governance issues described in the SAGGCS are repercussions from the National Water Act. One aspect missing in the institutional scene setting is that the White Paper on Water Policy that preceded the National Water Act strongly urged that groundwater, being a complex and difficult to understand resource, should only be managed where there is a strong and urgent need to do so. The National Water Act appears to have overlooked this advice, as did the SAGGCS, leading, it appears, to the unwritten assumption, that all groundwater in South Africa needs to be managed. It is suggested that this oversight is the root cause of many of the groundwater governance problems in South Africa since it leads to resources being applied to situations where those resources are not needed, and thus to a shortage of resources where these resources are needed.

The SAGGCS unwittingly supports this argument – that groundwater should only be managed when there is a strong and urgent need to do so – with its arguments on Transboundary Aquifers. The SAGGCS argument is that there is little need for transboundary cooperation because the majority of the aquifers are low yielding, low storage, and local affairs. In other words abstraction one side of a national boundary is unlikely to have significant impact on the other side of the boundary. One could just as easily apply this argument to farm boundaries.

Missing from the SAGGCS is a working definition of what the authors understand to be groundwater governance, and good groundwater governance. Without this definition, there will always be uncertainty as to whether all the processes described in the SAGGCS are somehow part of groundwater governance, or part of something else. Since it is a World Bank study, and since it is strongly guided by the World Bank sponsored report of Foster et al. (2010), the authors presumably subscribe to Foster et al.'s (2010) definition of groundwater governance: a process that

"is focused on the exercise of appropriate authority and promotion of responsible collective action to ensure sustainable and efficient utilization of groundwater resources for the benefit of mankind and dependent ecosystems."

Thus, according to Foster et al. (2010) groundwater governance is defined as both a process and the goals of that process. Others, for example Lautze et al. (2011) have maintained that governance is essentially a process, and the participants in the process should define their goals as part of the process. If one uses governance at the national government level the differentiation between defining the *process* of

governance and the *goals* of a governance institution become much clearer. National governance would not be defined as the process of electing a government so that they can drop bombs on another country. National governance would be defined as the process of electing a government so that they could give effect to the will of the people. If that will was to drop bombs on another country, then so be it, but that defines one of the aims of one particular governing institution, not the aims of national governance in general.

That the SAGGCS are probably subscribing to the definition of Foster et al. (2010) can be seen in the fact that the SAGGCS assigns both aims and process to their implied definition of groundwater governance. The implied aim of groundwater governance in the South African case study appears to be the sustainable use of groundwater although nowhere is this explicitly stated. Sustainable use appears to imply preventing over-abstraction and pollution of groundwater resources. The governance process implied appears to be anything that realises the aim. However, it is repeatedly implied that the goals are taken as given, that some higher authority such as national government or a Catchment Management Agency will decide on goals that are already given, and somehow the end user will be the one implementing these goals. However, nowhere is it explicitly, or implicitly stated how all the higher level rules will lead to local level governance. Local level governance is seen as essentially an implementing and providing feedback function. Nowhere is the local governance agency given any right to choose the rules it wants to implement, or the power to implement those rules.

The previous paragraph contains a degree of speculation regarding what the SAGGCS standpoint is on the definition of groundwater governance. It would have been more helpful if the definition of groundwater governance had been explicitly stated. 'Good governance' appears to be equated to having the 20 point check list, formulated by Foster et al. (2010), in place. However, a closer inspection of the origins of the 20 point checklist in Foster et al. (2010) reveals that there have been no case studies that have proven that the checklist will lead to good groundwater governance. Instead, the value of the checklist is based on the authors' and GW-Mate experience. In other words the 20 point checklist is essentially expert opinion rather than factually based. This is not to denigrate the 20 point checklist because it seems reasonable to assume that if all the checkpoints were in place then groundwater governance would be of a very high and effective standard. But more important questions are:

- How to put the provisions in the checklist in place?
- Are some provisions more important than others?
- Are some provisions just 'nice-to-have' rather than essential?

These concerns are amplified by the way the SAGGCS seems to over-focus on the enabling framework – the layers of nested and overlapping systems that include many national strategies adopted by the DWA, as well as the parallel regulatory systems that impact on groundwater implemented by other national and regional institutions. These strategies include the National Water Resource Strategy, the Groundwater Strategy, and artificial recharge strategies. Other Departments that impact groundwater regulatory process are, inter alia, the Department of

Environment Affairs and the Department of Mineral and Energy Affairs. It is easy to focus on these strategies and forget that local governance has to be done by a small group of individuals, or just one individual, at the local level, using a local system. At the end of the day groundwater governance decisions revolve around a groundwater user switching on, or not switching on, a groundwater pump; switching abstraction to another location; not growing crops that consume so much groundwater; or by waste disposers choosing or being coerced to dispose of their waste at point A or point B; and other very local decisions.

The focus on the hierarchical and overlapping layers can seem like using a 'sledgehammer to crack a nut', especially since local motivation to make local decisions seems to get lost in the maze of hierarchies. This raises the question of whether or not it would be more effective just to focus on giving effect to a local governance system, rather than all the enabling and supporting frameworks. Despite these frameworks it seems that making local governance a reality is simply a 'wish'. There is a vague hope that it will 'happen' without active problem solving and the implementation of solutions.

Consider information systems, and private databases. It could be queried whether it is necessary for all the data to be shared for governance to work. It might be fairer to say that steps like this would make existing governance more efficient and effective, but would not necessarily be sufficient to provide the catalyst to initiate the governance process. A distinction needs to be made between what would make existing governance more effective, and what would act to trigger a governance process where there is none currently.

Therefore, a key concern of this study is that the existing strategies are all about making governance more 'efficient', but neglect to provide the stimulus for the initiation of groundwater governance. In other words the strategies are too concerned with improving a hypothetical process, rather than generating a practical process.

Does this mean that a bottom up approach is being advocated? Not necessarily. It means putting more focus on the local institutions that are going to do the local governance.

The SAGGCS study seems to follow the conventional wisdom that lack of capacity is the problem and overcoming this deficiency will provide a solution. This logic is seriously flawed. Increasing the number of trained hydrogeologists working for the DWA, and increasing the overall capacity of DWA, are not strategies that will, on their own, do anything to give effect to local groundwater governance. If one tries to unpack this strategy it would appear that the assumption is that if an increasing amount of resources are made available to the DWA, then local groundwater governance will spontaneously 'emerge'. A more practical strategy would be to divert existing resources (such as capital and expertise) to Common Pool Resources (CPR). Low yielding aquifers should be treated as de facto private property, unless there is a cost-benefit study that shows that intervention is needed. In other words identify the strategic aquifers and manage accordingly.

It is the opinion of this report that this is primarily a systems design problem, and secondarily a significant capacity problem. If there are limited resources they can be

prioritised and focused on a priority area. If there are only one or two experts in the country their knowledge can be leveraged.

It is better to work with a less sophisticated and pragmatic approach to water resources management than attempt to build and implement a utopian and unachievable strategy.

3.3.4 DETAILED DISCUSSIONS OF SELECTIVE AQUIFERS

3.3.4.1 Botleng Dolomite Aquifer

According to SAGGCS the Botleng Dolomite Aquifer problems are known, the solutions needed to resolve the problems are known, but according to the report, the Delmas municipality 'lacks the capacity' to implement the solutions. This generates two concerns:

- Is the Delmas municipality really the appropriate governance institution to implement the solutions? It was noted the problems were caused by groundwater over-use by agriculture. This would imply that organized agriculture should also be involved in implementing a solution (and defining the problem) if a genuine participatory approach is to be used.
- 'Lacks capacity' is something of a catch-all term and could be applied to a lot of spheres. Capacity needs to be more clearly defined e.g. technical capacity or skills capacity.

And additional concern is the public participation process. Although it is a well-meaning concept, it is important to establish if the process is happening and if it is happening how effective it is. The level of adequate participation also needs to be established. Should the public participate in the rule making and should they participate in the enforcement of rules? Or should actors higher up in the chain create and enforce the rules? If public participation is a proven and effective process, how will actors from the bottom up be linked in practice to achieve improved groundwater governance?

The Botleng Dolomite Aquifer study has shown that the creation of a management plan does not guarantee success. The SAGGCS report asks why the management plan was not implemented. This report, not the SAGGCS report, suggests that the reason for the failure of the plan is that it was compiled by technocrats who have neither the social capital to get the 'implementers' to buy into the plan, nor the authority to force their measures through. This once again highlights the need to clarify what 'lack of capacity' means. It could be argued that rather than laying the blame with the Delmas Municipality, there is a lack of intellectual capacity among strategic planners, higher level institutions and natural scientists and a lack of appreciation for the 'social capital/capacity' that is required to make governance work.

Conversely, if 'groundwater governance' is something only decreed by a higher authority with regard to issues such as groundwater over-abstraction, the formation of sinkholes and pollution, then surely the higher authority should carry out the implementation as well. Why is low-level consultation needed if decisions are made at a higher level?

The above comments may appear unduly critical and argumentative but serve to emphasize that from examples such as the Botleng Dolomite Aquifer it can be surmised that there is a strong need to 'unpack' the overall groundwater governance system. It is hoped that the 'unpacking' process will bring a clearer understanding to a system that is currently riddled with implications and assumptions that few people seem aware of.

3.3.4.2 Gauteng Dolomite Aquifers

Steenkoppies is currently in the process of forming a WUA and the formation of the WUA is strongly supported by local farmers. Farmers want the technical equipment to enable them to undertake data collection. While this is a positive step, the SAGGCS report states that DWA's role is not clear. Once again, this highlights the weak linkages in the system.

As in the case of the Botleng Aquifer, knowledge exists to deal with most of the groundwater issues. However, the problem is not only the lack of human resource capacity to implement the recommendations from various studies, but also the political will by stakeholders involved to act in the interest of all.

Thus we have a pattern for the Botleng and Gauteng aquifers:

- Scientists do studies to understand the problem.
- Scientists make recommendations to resolve the problem.
- Stakeholders are seen as providing inputs to the management process, inputs that may or may not be considered, rather than as controlling the process.
- The stakeholders or the proxies do not implement the recommendations.

This report suggests that the reason the recommendations are not implemented is because there is no motivation or incentive for groundwater users to give up short-term benefits for potential, but vague, long-term benefits that may be of no value to them currently.

This report also argues that the number of groundwater reports (and the funding that has backed up their creation) demonstrates that there is substantial hydrogeological knowledge in South Africa. This might suggest that the real problem is the inappropriate and ineffective use of resources rather than a lack of resources.

This leads to an important question: why persist with conducting scientific groundwater studies if their findings are rarely implemented?

3.3.4.3 Houdenbrak Basement Aquifer (Dendron)

According to the SAGGCS report very little monitoring is carried out in this aquifer. In addition, very few scientific assessments have been done, management plans are not in place and little progress has been made with regard to the establishment of water institutions. Thus groundwater governance is almost non-existent. Although there have been warnings given regarding the unsustainable use of the resource over the last 30 years, the aquifer continues to provide an economic supply of groundwater every year.

If a resource has been 'overused' for 30 years, has essentially no governance system in place and remains viable, it is tempting to ask these controversial questions:

- Is groundwater governance really needed?
- Have scientists made accurate determinations regarding the sustainable rate of use for the aquifer?

These provocative questions serve to challenge ingrained and stereotyped assumptions about groundwater governance. The assumptions include:

1) Groundwater use has to be controlled by a higher authority for it to be managed properly. ['Control' in this instance means relatively detailed measures like specifying abstraction rates. It is accepted that DWA has overall responsibility for the nation's groundwater, but responsibility can be effected without necessarily resorting to micro-management.]
2) Groundwater scientists have to be utilised for groundwater use to be properly managed.

Whether these assumptions are justified or not will be investigated further in the remainder of this project.

3.3.5 CONCLUDING REMARKS

The SAGGCS is a very thorough and comprehensive study. The remarks made in this review are somewhat critical, controversial and possibly even unsubstantiated. The intentions of the remarks made in this review are to encourage readers to consider groundwater governance from a wider perspective and to further open up the debate on the issue of governance. The SAGGCS study creates the impression that the NWA and the strategies to implement it are substantially without fault, and that the only 'flaw' is lack of capacity. This review seeks to encourage readers to think more broadly and critically about groundwater governance and to challenge standard thinking on the subject. Should the effectiveness of the NWA be questioned? Can the NWA engender good groundwater governance? Will addressing capacity issues improve groundwater governance?

Using the World Bank's checklist approach (as used in the SAGGCS study) may 'straitjacket' the debate. It creates the assumption that if all items on the list are 'checked' that good groundwater governance will automatically follow. This is unproven. In addition, there may be items missing from the list that are required to create good groundwater governance.

Of course, a checklist approach does have its advantages. It allows a particular case study to be investigated in a systematic way and allows meaningful comparisons to be made between case studies from different regions. However, given that the academic literature of groundwater governance does not provide evidence to substantiate the World Bank's 20 point checklist, it can be inferred that the checklist is based on expert opinion rather than fact. Since the area of groundwater governance knowledge is so limited it is plausible that the checklist may not be adequate and that expert opinion is not yet well informed enough to draw up a truly comprehensive list. Surely it is therefore prudent to widen scientific enquiry by asking open-ended questions rather than being constrained by the checklist?

A major thrust of this project is to establish (if possible) what other issues exist outside of the checklist.

Although the SAGGCS study emphasizes the 'science' perspective for the improvement of groundwater governance in South Africa, it serves as a reminder that only when science, society and institutions are brought together can good groundwater governance become possible.

3.4 Review of Sub-Saharan Africa Regional Consultation Report on Groundwater Governance (Krhoda, 2012)

3.4.1 OBJECTIVES

The aim of this review is to broaden the insights obtained from the review of the groundwater governance issues in South Africa, by looking at the situation in sub-Saharan Africa as a whole as portrayed by experts at the Africa Consultation.

3.4.2 BACKGROUND

The report outlines proceedings at a regional consultation on Groundwater Governance that was held in Nairobi, Kenya, in 2012. The regional consultation stemmed from a Global Environment Facility (GEF) Project entitled 'Groundwater Governance: A global framework for country action'. The impetus for the GEF project was the global concern for the 'depletion and degradation of groundwater' as a result of increased pressure from population growth, climate change and increased urbanisation. Addressing the threats to sustainable groundwater use would require improved governance at various scales and levels. The regional consultation, as part of the global effort, sought to look at regional groundwater issues and experience and find recommendations to address weak governance, limited knowledge and the low profile of groundwater. The Project refers to the quest for solutions as a Framework for Action (FA).

The first part of the consultation report deals with questionnaires that were handed out to participants before the regional consultation meeting. The number of participants from each region and institution is listed but the detailed responses to particular questions seem to fall under a 'separate cover'.

3.4.3 CASE STUDIES

Some case studies are described in bullet form in Plenary 3 and in others in other parts of the document. A summary of the seven studies are presented below:

South Africa*:*

- Policies, legislation and institutional arrangements made at a National level while groundwater management carried out at a local level.
- Strategic Plans for water reviewed every five years.
- Authorization required for abstraction but not for drilling.
- Limited hydrogeological skills and information.

- A need for governance to include stronger focus on local participation.
- A lack of investment in groundwater leads to higher costs because of the degradation of resources and the environment.

Uganda:

- Stakeholder participation encouraged through institutional framework.
- Management of groundwater and surface water integrated.
- Comprehensive monitoring networks and assessment in place (local, district and national level).
- Groundwater management decentralised.
- Policies and regulations built on the principles of Integrated Water Resource Management (IWRM).
- Overriding legal document is the Constitution of Uganda which recognises the government's duty to set regulations and standards.
- Challenges facing groundwater governance include rural populations, rapid urbanisation, and increased water demand from the industrial and agricultural sector.

Kenya:

- Groundwater governance is underpinned by the principles of IWRM.
- Water resource management is decentralised (6 catchment area authorities).
- A permit system is in place for groundwater abstraction, wastewater management and pumping regimes.
- Challenges include the uneven distribution of groundwater, a shortage of data and information, poor monitoring networks, inadequate policies and strategies, lack of awareness of groundwater, and a lack of knowledge of transboundary waters.

Sahara and Sahel Observatory/Lullemeden Transboundary Aquifer:

- The location of the aquifer (traversed by the Niger River) is a principal factor in the sustainability of the aquifer.
- At present the aquifer is not degraded but is under pressure is increasing pressure from population growth and climate change.
- Currently seven countries are involved in the Niger Basin authority.
- Challenges facing the management of the aquifer include a lack of data and information, poor knowledge of the aquifer, and reduced water quality and quantity.

Zambia (groundwater governance in urban areas):

- Poor urban planning and an uncoordinated approach to groundwater governance has led to degradation of water resources.
- Aquifers require protection from pollution sources.

- Chemical data on the urban aquifer shows evidence of poor urban waste management.

Liptako-Gourma River (Burkina Faso):

- Has seven management administrative regimes.
- Fishermen, and an Association of Water Users are included in institutional arrangements.
- Legislation and regulations are in place, as well as a training programme, a new water code and a national communication on water and sanitation.

Burkino Faso (groundwater governance in rural water supply):

- Policies on agriculture and pastoralism have been put in place because of threats from climate change.
- The governance area is 274 000 km^2 with a rainfall of between 400 mm and 1000 mm per year.
- Strategies to ensure government funding need to be formulated in order to develop infrastructure for groundwater management projects.

3.4.4 GENERAL THEMES (PROBLEMS AND SOLUTIONS)

3.4.4.1 Background

Discussions/debates and topics were dealt with under the titles of 'Plenary Sessions' and 'Break Out Sessions'. The structure of the discussions is not entirely clear in the report. Representatives from various regions made presentations – some on particular local problems and others on general groundwater governance issues. The outcomes of most of the discussions seemed to highlight standard problems faced in groundwater management today and many points were repeated at different times and under different topics. It therefore seems reasonable to summarize these discussions by identifying general 'problem' themes and identifying recommendations that participants made to address these 'problems'.

3.4.4.2 Climate Change

There has been increased pressure on groundwater resources because of the impact of climate change on surface water resources. A benefit of climate change is that it has placed more value on groundwater. In general, it is recommended that policies are either created or revised and that groundwater management is accountable and transparent. More skills are required in the sector, better data collection, a stronger institutional framework, better use of technology, and an active 'search' for funding to improve management.

3.4.4.3 Governance

The general recommendations for improved groundwater governance included:

- Regulation of groundwater at a local level.
- Groundwater governance needs to be promoted outside of the hydrogeological world.

- The benefits of groundwater governance versus the costs of not implementing good governance need to be established.
- Best practice in borehole location and monitoring, pumping regime and regulation should be applied.
- Governance should fall within an Integrated Water Resources Management (IWRM) framework.
- Capacity is needed for groundwater governance.
- The economic importance of groundwater needs to be established.

A good preliminary assessment of groundwater should be in place in order to inform good governance. Where aquifers are used, development should be sustainable. Lessons should be taken from examples of good groundwater governance. Good governance requires decentralization of management. The profile of groundwater needs to be raised within institutions.

3.4.4.4 Financing

The argument for good groundwater governance needs to be solid in order to justify funding. Various sources of funding should be found including from philanthropists, banks, climate change initiatives, foundations, the private sector and development partners. Other points made included:

- The benefits and value of groundwater need to be promoted more effectively in order to secure funding.
- A one-basket fund for water resources needs to be created.
- There is a need to secure revenue from groundwater users and polluters.
- Poor data sharing at a regional level hampers the financing of projects.
- Costs need to be recovered where investments in groundwater have been made.

3.4.4.5 Groundwater information, knowledge and data

A bottom-up communication channel as well as between users is important. The development of local institutions needs to be in place to make this type of communication possible. Groundwater knowledge and information needs to be disseminated through education and exchange. Skills in the sector need to be improved. The media needs to be used effectively. Groundwater education needs to be reformed in order to improve the groundwater skills base. Communication between researchers and policy makers needs to be improved.

3.4.5 CONCLUDING REMARKS

For the purposes of this report it might be fair to summarize the results of the consultations into these overall perspectives:

- The attendees provided numerous inputs regarding what they perceived to the problems with groundwater governance.
- The attendees provided numerous inputs regarding what they perceived to be essential components and prerequisites for good groundwater governance.

- The need for significant increases in human capacity, financial funding, data, education and awareness, decentralization, and integration were some of the more frequently mentioned perceptions.
- The attendees provided little input regarding what they perceived needed to be done to initiate groundwater governance. Presumably the attendees' assumption was that once all the components for good groundwater governance had been identified and made available then these components would somehow spontaneously combine and good governance would emerge without the need for any deliberate intervention.

The tension that was identified in chapter 3 of this report between the governance *process* and governance *objectives* does not seem to have been resolved (or addressed) at the Africa consultations. The motivation for the GEF global governance initiative was to address groundwater depletion and degradation at various scales. That is an *objective*. However this report has tried to make the point that governance is primarily a *process*. This process, if it is to be transparently, democratically and equitably implemented, needs to decide on its own objectives. By insisting on pre-determined objectives, such as addressing groundwater depletion, the process could well be wrecked. But by not insisting on pre-determined objectives it is possible the (local) groundwater governance regime could well decide on goals that are not consistent with the broad objectives of society, such as sustainability, that motivated the governance initiative. Hence the use of the word 'tension' to describe the possible conflict between the high level objectives that motivated the calls for local governance, and the local objectives of local groundwater governance implementers. It would appear that a good governance system would need to be capable of addressing this tension.

3.5 General Literature Review

3.5.1 OBJECTIVES

The objectives of this literature review are to:

1) Characterize the broad, overall types of groundwater governance,
2) Characterize the overall success rates for groundwater governance,
3) Attempt to find general rules for good groundwater governance that could be imported directly to the South African setting, and/or:
4) Attempt to find general methodologies for designing specific good groundwater governance rules that could be applied to the South African setting.

3.5.2 METHODOLOGY

The overall approach was to review a selective number of investigations that were deemed sufficiently representative to allow the objectives of the literature review to be characterized.

Because there are so few examples of good groundwater governance, there seemed little point in looking at examples that didn't work, identifying the factors that

prevented governance from being effective, eliminating them, and somehow trying to identify good governance from what, if anything, remained. There was no guarantee that the 'positive' would somehow become clear once the 'negative' had been eliminated.

3.5.3 REVIEWS

3.5.3.1 Indian subcontinent and the Middle East (Van Steenbergen, 2006)

In many ways the groundwater governance picture painted by Van Steenbergen is the antithesis of the South African groundwater governance system. Instead of governance dominated by Water Acts, Water Law, Water Strategies and top-down attempts to 'control' groundwater use, Van Steenbergen describes many case studies where groundwater governance is primarily a local system initiated by local stakeholders for the benefit of local stakeholders, usually with little or no support from higher institutions.

Van Steenbergen argues that groundwater use is a major issue in many parts of the globe, and that although apparently reasonable solutions have been proposed, such as water pricing, and defining water rights via allocations, licensing etc., there is little evidence that these solutions work. He therefore explores a third option – local groundwater management – as the primary tool for ensuring sustainable groundwater use. For the purposes of his study, Van Steenbergen defines local management as the regulation of groundwater use by local stakeholders.

Van Steenbergen shows that:

- Local groundwater management can be very effective.
- While groundwater overuse was the common issue in all the cases investigated, there are many different ways in which this issue can be the catalyst for local stakeholder management. In some cases a local non-water institution can take on the job of water management. In other cases the initiative can come from regional or state government. In some cases education programmes from NGOs can be the catalyst. In yet other cases local management can arise almost spontaneously as the result of the initiative of a single, concerned water user.
- Local groundwater management is possible without well-defined formal management structures.
- Local groundwater management is possible without formal rules. Social pressure, adherence to norms, and leading by example can all give effect to good local groundwater management.
- The rules used are very simple, based on parameters that anyone can monitor: a ban on certain types of wells, zones where no well development is allowed, no drilling beyond a certain depth, water must be used for drinking water only, or a strong discouragement of water-intensive crops.
- Promoting local-scale groundwater regulation does not have to be a difficult, costly or sensitive issue.
- The importance of universal access. New applicants are not denied access to water. Existing users are not compelled to give up their access to water. Instead

the groundwater resource is seen as a communal resource that anyone can access within certain limitations. In some cases this communal approach goes so far as to link up the boreholes and wells in a network of pipelines so that if one borehole fails, other boreholes on that 'grid' meet the shortfall.

- Pricing is not an effective tool in groundwater management since the cost of abstraction is usually only a small fraction of a water user's costs.

While higher levels of government can be useful according to Van Steenbergen's study, their usefulness appears to be limited to functions such as supporting the development of local governance, supporting the use of basic hydrogeological data, and giving effect to decisions to punish transgressors made by the local groundwater management body. In all these functions higher government plays a support role and is not directly involved in the decision-making per se. Van Steenbergen argues that the water rights and concessions based approach [the approach enshrined in South Africa's NWA] will require so much time and social energy before it can be made implementable (if it can be implemented at all) that it would be better to spend that time and energy setting up functional [local] organisations using new [and simple] rules and norms, and describes informal, yet effective local management structures that can be set up in a matter of weeks or months.

Interestingly, Van Steenbergen also shows that steps to improve water efficiency, e.g. irrigating by sprinklers instead of flooding, and steps to augment over-used resources by for example artificial recharge, do not necessarily reduce the stress on the resource, but instead are more likely to increase the area under irrigation.

3.5.3.2 Yemen (Taher et al., 2012)

This investigation gives further examples of locally driven groundwater governance initiatives that work, as compared with top-down approaches that are assumed to work (but may not). While much of the research on groundwater governance focuses on government and other institutional programmes and projects and how stakeholders might take part in these programmes and projects (the 'top-down' approach), Taher et al. tackle the issue from the other direction. They look at local groundwater governance initiated by the communities themselves, and how government can support and participate in these initiatives.

Taher et al. describe how Yemeni farmers have responded to rapidly falling water levels over the past decades by implementing local rules and regulations on the use of groundwater. The exact details of these regulations vary from region to region, but in general the local governance of groundwater was a natural extension of strong, existing local governance provided by the local sheikh family, using rules based on centuries of tradition. Rules are set on how far new wells must be located from existing wells and springs, and on how deep boreholes may be drilled. Typical rules on minimum distances are 500 m from an existing well, further if the well is a source of drinking water, and 2000 m for springs. Not only are these rules set, they are enforced. For example a surreptitious attempt to construct a 25 m deep well, 200 m from a drinking well, during night time was discovered, and the culprit responded to social pressure and filled in the well. In another instance a local community managed to coerce a National Authority to overturn it's granting of a permit to a farmer to irrigate because of concerns for their drinking water, where

groundwater was the only source. Yet another approach is for the local community to lodge complaints to the National Authority whenever unlicensed drilling is about to start.

This strong local governance, however, does not necessarily prevent all groundwater problems. Some wells continue to dry up. Taher et al. (2012) argue that this problem could be better prevented if modern hydrogeological science could somehow be incorporated into the centuries old traditions of groundwater governance, and are of the opinion that much more could be done to make hydrological information from technical studies and official monitoring available to water users. In fact, Taher et al. (2012) go as far as to say that many of the most important governance improvements have not come from strict law enforcement or punitive sanctions, but instead through improved communication, local groundwater monitoring, and the sharing of information. In other words, good governance came from cooperation between stakeholders rather than by individuals or institutions acting on their own. They also suggest a role for government in managing groundwater resources by informing and enabling local problem solving, rather than by 'command and control'. They also suggest: '*In fact it is hard to see how groundwater use in Yemen can be regulated without it being built on a foundation of local acceptance and initiative.*'

The following comment provided by Taher et al. seems especially relevant and is quoted verbatim and in its entirety. Emphasis through underlining has been provided by the current authors:

"A particular challenge in dealing with groundwater is that it is invisible, making it hard to understand and hard to monitor. Thus, the feasibility of management will often depend on finding rules that can be monitored, rather that attempting management that depends on extensive technical analysis. Governance of groundwater is more likely to succeed if it is based on simple rules that are easier to understand and monitor, rather than complex, technically based licensing regulations. Considering the feasibility of monitoring helps to understand the measures communities have already undertaken, those that might be most likely to work, and the ways in which technical information might help to enhance understanding and governance of groundwater."

Thus the lessons that can be learnt from Taher et al.'s Yemen investigation are that:

- Excellent local groundwater governance can arise from solely local initiatives without any government involvement.
- The basis for this good governance seems to be a tradition of strong local governance plus the need for groundwater governance because of water problems.
- Government attempts at governance without obtaining local commitment first, can be futile.
- The best place to start improving local groundwater governance is where a strong interest in groundwater matters already exists.
- Special attention is given to wells supplying drinking water. For example, if the general zone in which the drilling of boreholes is excluded is 500 m, this is likely to be doubled to 1000 m if it a drinking water source that is to be protected.

Can these lessons be applied to the South African situation?

The obvious first step would be to query the assumption that the existing top-down management approach is implementable if more 'capacity' could be or is provided. It might be more prudent for higher institutions like DWA to attempt to achieve their goals via more emphasis on support and indirect regulation, and less emphasis on direct regulation. The second step would be to identify areas where groundwater issues are arousing local concerns and assist with providing information, assist with the formation of structures, impose administrative law when asked for, and so forth. The third step might be to attempt to kindle community interest where the state has knowledge of impending water problems that are not obvious to the community.

3.5.3.3 Mexico (Wester et al., 2011)

The optimistic view of Van Steenbergen (2006) is that local groundwater management can work or can be made to work in a variety of situations, and can be triggered by a range of factors using many different types of controls. In contrast, Wester et al. hold more pessimistic views. Wester et al. suggest that, as in the Mexican case, there is little global evidence of local (or for that matter ***any***) groundwater governance working, even in cases where there has been a concentrated effort to make local groundwater management work.

Wester et al. describe the process of Water User Association (WUA) creation in Mexico between 1995 and 2006. The WUAs were created as part of a process to attempt to halt the fall in groundwater levels that had been steadily declining for some 50 years. In addition, extensive programmes were put in place to:

- Understand the hydrogeology via extensive aquifer studies and the development of a comprehensive database, as well as water level monitoring.
- Invest in water-use efficiency and supply augmentation.
- Increase user awareness and involvement in water management.
- Develop groundwater management models.

According to Wester et al. the thinking was that by creating the right environment and providing the right information, the groundwater users would somehow come to the conclusion that groundwater use had to be reduced, and take the necessary steps to bring about the reduction themselves.

However, despite all the financial, human and scientific resources that were invested in addressing the problem of declining water levels, there were negligible benefits, and water levels are still steadily declining. Wester et al. suggest two main reasons for this:

- A lack of motivation among the water users to become involved in the WUAs. Users see no obvious benefits to them, fear the loss of water rights, and are more concerned with e.g. the commercial gain from food production than conserving groundwater resources. Users generally regarded groundwater management as a government responsibility.
- A lack of authority and responsibility delegated to the WUAs. Water rights and concessions were still decided by government, the WUA having little more than an advisory role. The WUAs had no authority to enforce any solutions even if they could find one.

For self-regulation to work, Wester et al. argue that far-reaching institutional changes would be required. The most important change would be functioning mechanisms to enforce groundwater legislation.

3.5.3.4 U.S.A. – High Plains

Thus far two broad approaches to groundwater governance have been described; the essentially top-down, water regulation-driven approach employed by Mexico and South Africa; and the bottom-up, stakeholder-driven approaches that have manifested themselves sporadically and locally in places like the Indian sub-continent and the Middle East. The U.S.A. High Plains constitutes a third broad approach – the dominance of private rights.

Historically, the US government has deferred water allocation to the individual states, with each state having its own body of water law derived from its constitution, legislative acts and court decisions (Sophocleous, 2010.) Thus the manner of groundwater governance can vary from state to state. This variation in water laws between states can be one of the reasons why large, regional aquifers, such as the High Plains aquifer are so difficult to manage in the USA.

The High Plains aquifer covers portions of South Dakota, Wyoming, Nebraska, Colorado, Kansas, New Mexico, Oklahoma and Texas. It is estimated that 312 km^3 have been withdrawn from the aquifer in total since it was first used, and that in the year 2000 some 26 km^3 were used (McGuire, 2011). In many places water levels have been steadily declining for 50 or 60 years (McGuire 2011). Because of the variability in the thickness of the aquifer some areas will be depleted before others if current abstraction patterns continue. Some areas are already depleted, while estimates for depletion in areas with greater thicknesses of saturated aquifer range from 25 years (McGuire, 2011) to 100 years (Little, 2009).

In American law a water right is a right to use a certain amount of water annually, at a certain point, forever, as long as the water right holder is not breaking the law and stays within the conditions of the water right (Peck, 2007). Four basic doctrines form the basis of groundwater rights in the High Plains (Peck, 2007):

- **Absolute ownership** – every landowner has the right to pump as much groundwater as they can capture without regard to the rights of others.
- **Reasonable use** – judged with respect to whether the *purpose* of the use is reasonable, e.g. irrigating a certain crop type, rather than reasonable in terms of the capacity of the aquifer or the needs of others.
- **Correlative rights** – (i) groundwater can be appropriated for non-overlying land use provided local overlying users are not harmed, and (ii) if the resource cannot meet the needs of the users, the users can be legally required to proportionately reduce abstraction until supplies match use.
- **Prior appropriation** – water rights are acquired by beneficial use rather than land ownership. The person who established their rights the earliest has more right to use that water than subsequent appropriators.

Of the states that contain portions of the High Plains aquifer, only Texas applies 'absolute ownership'. The other states: South Dakota, Wyoming, Nebraska,

Colorado, Kansas, New Mexico and Oklahoma; apply a mix of one or more of 'reasonable use', 'correlative rights' and 'prior appropriation'. However, none of these approaches appear to be sufficient to halt the decline in water levels or other problems in the High Plains aquifer. Thus, the states concerned have adopted various 'critical area' legislation (Sophocleous, 2010) that attempts to limit withdrawals to recharge after extensive studies have been completed. In Texas and Nebraska 'critical area' management is implemented at the local level, while the other states implement 'critical area' management at state level, or at both state and local level. While local user associations appear to be more popular and enjoy more support by the users, they are reluctant to impose upon themselves the severe measures needed to address serious over-abstraction (Sophocleous, 2010).

There have been some successes with the High Plains aquifer management initiatives (Sophocleous, 2010):

- The Texas Groundwater Availability Modelling program has increased stakeholder awareness and promoted the importance of groundwater management.
- The implementation of the Walnut Creek Intensive Groundwater Use Control Area in Kansas that mandated a water-rights reduction of some 50% to 28 million m^3/year, via increased irrigation efficiency, switching to higher profit crops, and some reduction in areas under irrigation.
- The Kansas 'safe-yield' management plans for five 'Groundwater Management Districts' that attempted to limit abstraction to recharge have caused some reduction in the rate of decline of water levels in these areas.
- Tax incentives for water users in Kansas to install water flow meters has resulted in 99.9% of all water use being recorded.
- In Nebraska the formation of flexible Natural Resources Districts enabled local rules to be set for groundwater allocations. However the Districts depend on state and federal institutions to enforce the allocations.
- The US Department of Agriculture Conservation Reserve Enhancement program provides financial pay-outs to owners who stop irrigating their land.

Despite these pockets of success, the overall trend in the water levels of the High Plains aquifer remains downwards, a pattern that seems to mirror the global trend where for each 'success' story there are hundreds of 'failures'. According to Sophocleous (2010) it is difficult to see this trend reversing in the High Plains until water 'rights' are replaced with water 'permits', since 'rights' are usually impossible to reduce using existing legislation. Replacing 'rights' with 'permits' would be deeply unpopular politically in a conservative, free enterprise system. It is unlikely that an elected government would risk losing electoral support by taking away those rights.

In the long-term these 'baby steps' towards direct regulation of groundwater in the High Plains could well be overtaken by indirect regulation. It might be inferred from Little's (2009) discussion of methods to conserve the High Plains aquifer that direct governance or local management of aquifers are essentially non-starters since these are not even mentioned as options. Instead, attention is given to indirect governance

such as reducing the subsidies for crops like maize that need to be irrigated in the High Plains, and financial incentives for dry-land crops and for grazing. National food security is possibly the ultimate controller of the situation in the High Plains (Guru and Horne, 2000). There seems little likelihood of a major change in attitude to the depletion of the High Plains groundwater until, or if, the Federal Government decides national food security would be better achieved by a gradual transition to sustainable agricultural practices in the area, or whether it would rather wait until all the wells run dry before intervening.

3.5.3.5 USA – California

While the state of Texas in the 19th century regarded groundwater as something so dark and mysterious that it could only be the work of the devil, the state of California in the 19th century was already implementing, or at least legislating, a form of IWRM, that acknowledged groundwater as a part of the hydrological cycle, and that acknowledged all environmental resource issues were interrelated. By 1903 the British common law doctrine of landowners owning everything beneath their land had been rejected in the California Supreme Court.

However, despite progressive legislation, the groundwater problems experienced by California seem as bad, or worse, than those experienced by less legislated regions throughout the world. The first case of land subsidence caused by groundwater abstraction in California was reported in 1931 (Grabert and Narasimhan, 2006). A groundwater overdraft has existed for some five decades (Grabert and Narasimhan, 2006; NASA, 2009). Groundwater depletion has been estimated as some 140 km^3 from the 1860s to 1961, and 80 km^3 from 1962 to 2003 (Scanlon et al., 2012). Problems with seawater intrusion caused by over-abstraction have also been in existence for a long time.

Since the 1970s, a plethora of yet more progressive legislation, including numerous Senate Bills, also seems to have had little impact on resolving the groundwater issues. The groundwater overdraft still persists. Indeed, Grabert and Narasimhan (2006) express their concern that the flurry of new initiatives may result in laws and policies that could be unclear, conflicting or redundant.

The obvious, but possibly simplistic, conclusion to draw from California's experience with groundwater management is that progressive legislation does not guarantee solutions to groundwater issues.

Everyone does not share this pessimistic view of the effectiveness of California's seemingly chaotic water laws. Hanak et al. (2010) argue that California has all the legal tools it needs to deal with groundwater management, and that the classification of groundwater as private property is not a significant deterrent to the use of these tools. The lack of direct regulation by California is a policy choice, rather than a lack of regulatory tools (Nelson 2011). Instead of intervening directly, California has created legislation whereby local agencies manage groundwater, either directly or indirectly via their mandate to manage a related issue such as surface water, and the environment. Nelson (2011) estimates there are some 2300 of these agencies, many of which are coming up with creative, innovative plans to manage groundwater without direct guidance from the State. Whether these plans

will, or have already, lead to successful interventions will require more research for clarification.

However, given the rich diversity and creativity of the groundwater management plans attempted by diverse agencies in California, this would seem to be fertile ground for further research into groundwater governance, and an alternative to simplistic local versus national models of groundwater governance implementation.

3.5.3.6 South Africa (Tosca-Molopo)

A recurring theme in this literature review is that examples of good groundwater governance tend to be anomalous. In other words, examples of good groundwater governance can sometimes be found, even where the norm is poor groundwater governance. Moreover, the reasons for the isolated examples of good groundwater governance are not immediately obvious; there are no obvious characteristics that can be universally exported; and there are many areas with the same mix of governance ingredients yet these areas exhibit ineffective governance. The Tosca-Molopo area is another example of an anomaly since it provides at least one incident of effective groundwater governance in a country that was shown to have typically weak to non-existent local groundwater governance, at least if one assumes that the Pietersen et al.'s (2011) case studies are representative of the country as a whole. The experience of these authors is that the case studies are representative rather than atypical.

Therefore, as is the case in many parts of the world, South Africa can claim at least one example of effective groundwater governance for all the hundreds of cases of ineffective governance. In South Africa's case the effective groundwater governance can be found in the Tosca area, close to the Molopo River that forms the boundary with Botswana. Large amounts of groundwater had been abstracted from a dolomite aquifer for irrigating crops. Water levels had been declining for many years, and stock farmers that used the overlying sand aquifer as a source of stock water claimed their boreholes were drying up.

The national government Department of Water Affairs (DWA) initiated the formation of a WUA in the area, commissioned scientific studies to ascertain the 'safe yield', and undertook a survey to verify lawful groundwater use (Van Dyk, 2005). Seven farmers had their groundwater irrigation facilities shut down and the rest had their abstraction cut by 30% (Fourie, 2011). Enforcement measures included:

- Removal of pumps from irrigation production boreholes.
- Sealing of irrigation boreholes.
- Recovery of costs.
- Restoration of permissions to use water once costs had been recovered, and an agreement had been signed with the WUA to comply with allocations of groundwater use or to follow correct procedures in cases of a disagreement.

The Tosca initiative seems draconian when compared with the rest of the country where groundwater governance is weakly enforced. What made the Tosca initiative so different? It could not have been the presence of a local WUA, since these have been established in other parts of the country without effect. Ultimately, it was not

the WUA that really effected the reduction in yields in the Tosca area, but rather the DWA.

The motivation for the successful intervention by the DWA cannot be solely declining water levels. Declining water levels are found in many aquifers in South Africa but have not prompted the DWA to intervene so vigorously.

A possible reason for the intervention is the conflict between different ('racial') groups of users. In many aquifers in South Africa where water levels are falling all the users are irrigation farmers and there are no group conflicts – although obviously individual conflicts arise if a particular farmer's boreholes dry up. In the Tosca case there were two distinct user groups. One group is the stock farmers (predominantly 'White') and the other, the irrigation farmers (predominantly 'Black'), with some elements of a 'racial' divide.

Whatever the motive for the intervention might ultimately have been, it is clear that there was a strong a motive. However, besides a strong motive, there has to be strong enforcement as well for good governance to take place. In this case enforcement was provided, not by the WUA, but by a national government department. The authors of this report would suggest that the reason the DWA was successful in this case was because of its focus. The DWA could focus its resources on one particular spot, and be effective, rather than ineffectively trying to regulate groundwater use in the country as whole.

Thus, the authors would argue that the Tosca case supports the argument that effective groundwater governance is best implemented at the local level. However, this is not local in the 'conventional' sense that local groundwater users can manage their own affairs by forming a tight feedback loop connecting motivations and controls. Here, focusing a national state apparatus on a very small area formed the tight feedback loop. The state was motivated to ensure that the groundwater was allocated 'correctly' according to its rules, and for once, acquired the 'muscle' to enforce those rules.

However, the situation has not been totally resolved. Even though the legally correct groundwater allocations were enforced, there are those that argue that the 'correct' allocations are still not fair because they continue to favour those who had the easiest access to capital and resources under apartheid ('Whites') and have done little to redress the inequities of the past. Another problem is that water levels are still declining despite the use being limited to the correct allocations. This demonstrates again that groundwater 'safe yields' cannot be determined with precision in advance. It would seem reasonable to advocate accepting this fact, and forming a groundwater governance system around the fact.

3.5.3.7 Australia – Namoi Catchment

This example is especially interesting because it tackles the issue of reserving water for environmental health rather than the more common problem of arresting declining water levels. Groundwater in the Namoi catchment is predominately used for irrigation and has been extensively monitored since the 1970s. Groundwater use has been typically slightly less than average annual recharge, except in droughts, when groundwater use has increased to approximately double the annual average

recharge (Ross and Martínez-Santos, 2010). The two main areas of concern (Ross and Martínez-Santos, 2010) were:

- Groundwater licenses that permitted, and thus could lead to, approximately twice as much being used as the current actual use. The concern was that if the 'dormant' groundwater licenses were exercised on a permanent basis then this could lead to serious groundwater depletion since the current use was only marginally less than average annual recharge. The over-generous license allocations appear to be a result of the state's enthusiasm to encourage development, and possibly the use of unrealistic recharge estimates.
- The existing license allocations did not take environmental requirements into account, and the Nature Conservation Council of New South Wales demanded that 30% of average annual recharge be reserved for environmental health.

A Water Sharing Plan was developed (Turral and Fullagar, 2007) using the legislation contained in the New South Wales Water Act of 2000. The development of the plan generated discontent and many of the irrigation farmers claimed that 100% average annual recharge was too conservative. The farmers' viewpoint is that more than this is recharged as a result of aquifers with lowered water levels being able to receive more recharge (Ross and Martínez-Santos, 2010). Another contentious point was the unfairness of reducing exercised rights ('beneficial use') by the same proportion as dormant rights. Ultimately, this was resolved by a 75%/25% weighting between active and inactive use (Ross and Martínez-Santos, 2010).

There were also many objections to what was perceived by many users as procedural unfairness. However, a plan for sharing the water was finally accepted and implemented (Ross and Martínez-Santos, 2010). A major motivating factor was State and Federal assistance to compensate for loss of income from reduced entitlements. Useful lessons that might be learnt from the Namoi experience are:

- The value of a higher level of government driving a local process where strong disagreements exist, especially where environmental health is an issue. It is difficult to imagine a local WUA, driven primarily by the profit motive, introducing rules that would benefit environmental health and decrease their profits.
- The value of financial incentives.
- The interesting concept of allocating a percentage of the resource, fixed for perpetuity, and freely tradable, rather than allocating a fixed volume.
- The number of people directly affected was only a few hundred, which facilitated negotiations and even allowed one-on-one discussions. This is a very favourable situation when compared with the thousands or even millions of participants that would have to be engaged in groundwater management in other countries.

Possibly the most important lesson to take away from this, is that finding a linkage between groundwater rules for environmental health and groundwater rules for economic prosperity, is difficult. While allocating 30% of average annual recharge to 'non-consumptive use' might well have seemed draconian to the irrigation farmers, it might also have been senseless. Groundwater for the environment is essentially a

geospatial problem rather than a volumetric problem. There is plenty of scope and value for hydrogeologists to inform and educate environmentalists (and themselves) about the true nature of groundwater and environment interactions.

3.5.3.8 Spain

The Spanish experience with groundwater governance is not dissimilar to that of countries like Mexico and South Africa. Tools analogous to South Africa's National Water Act exist in Spain, as do institutions analogous to South Africa's CMAs and WUAs. Spain's approach to the registration of groundwater use and groundwater licensing are also not dissimilar to South Africa's. The overall progress with groundwater governance in Spain is also not dissimilar to the progress in South Africa. There are few obvious success stories and much still needs to be done.

However, what is different about groundwater governance in Spain is that it is has been much more intensively researched than groundwater governance in South Africa. Therefore, although there may be little of practical value to learn from the Spanish experience with groundwater governance, there is a lot that can be learnt regarding research methodologies. For example much can be learnt regarding research methodologies from the work of Lopez-Gunn and Cortina (2006) who evaluated good governance in eight Groundwater Users' Associations (GWUA) in Spain by analysing the number and effectiveness of selected key governance attributes in place.

Lopez-Gunn and Cortina's (2006) assumption was that institutions with these governance attributes in place will fare better in the sound management of aquifers than those institutions without those attributes. In some ways, this is a more sophisticated approach than the somewhat crude use of 'successful interventions' as an indicator of good governance. The Lopez-Gunn and Cortina (2006) approach is more sophisticated because it allows for the identification of good, i.e. robust and sustainable, governance that has not yet required intervention, or has possibly prevented the more obvious groundwater 'crises' discussed elsewhere in this report. The 'successful interventions' indicator approach will most probably fail to identify these examples of good governance institutions. On the other hand what may be perceived to be good governance using the Lopez-Gunn and Cortina (2006) approach may simply be cases where the resource is not yet being used at or beyond its capacity, and/or there have been no negative impacts – ecological or otherwise – associated with that use, and there has simply been no need for governance interventions. The effectiveness of the governance institution has therefore not really been tested.

The indicators used by Lopez-Gunn and Cortina (2006) were:

- Salience – how dependent are the users on the resource for their livelihood?
- Common understanding of the resource.
- Low discount rate – users apply a low discount rate in relation to future benefits achievable from the resource.
- Trust and reciprocity.
- Autonomy.

- Prior organisational leadership.

Of the eight GWUAs discussed by Lopez-Gunn and Cortina (2006), only one, Catalana, met all these requirements, and the others typically met less than half of the requirements. Not only is the Catalana GWUA effective in protecting the individual interests of users, but has also evolved into a body that protects the 'public good' aspects of groundwater, e.g. preventing undesirable ecological impacts. Interestingly the Catalan GWUA was not the smallest studied, so the reason for its 'good governance' rating must lie elsewhere. Lopez-Gunn and Cortina (2006) assign much importance to the trust that has developed within the Catalana GWUA and the trust and good working relationship that exists between the GWUA and the higher-level water authority that oversees the GWUA. Indeed, Lopez-Gunn and Cortina (2006) attribute much of the success of the Catalana GWUA to the over-arching, higher-level water authority, and go on to posit a general case – that a healthy, higher-level authority is probably a prerequisite for a GWUA to be effective. This is hardly a surprising conclusion where Lopez-Gunn and Cortina describe the norm for higher-level institutions in Spain as 'paralyzed' because of a lack of capacity and a lack of continuity.

3.5.3.9 Spain – Australia: comparison

One of the few cases where Ostrom's Design Principles (Ostrom, 2009a) have been investigated in a groundwater setting is in a comparison of groundwater governance in Spain and Australia (Ross and Martínez-Santos, 2010). Ostrom (1990, 2001, 2005, 2009a) has observed that the more of these design principles (Table 2) that are present, the more likely the governance of a common pool resource (CPR) is likely to be sustainable, and conversely, the fewer of these design principles that are present, the more likely that governance is likely to be unsustainable. Since groundwater is, or can be, a CPR, these design principles ought to apply to groundwater. However, one caveat is that the Ostrom Design Principles (ODP) were formulated for governance systems that were created by the users of a CPR themselves, rather than a system imposed by a higher institution.

Table 2. Ostrom Design Principles (Ostrom, 2009a)

1A. User Boundaries: Clear and locally understood boundaries between legitimate users and nonusers are present.
1B. Resource Boundaries: Clear boundaries that separate a specific common-pool resource from a larger social-ecological system are present.
2A. Congruence with Local Conditions: Appropriation and provision rules are congruent with local social and environmental conditions.
2B. Appropriation and Provision: Appropriation rules are congruent with provision rules; the distribution of costs is proportional to the distribution of benefits.
3. Collective Choice Arrangements: Most individuals affected by a resource regime are authorized to participate in making and modifying its rules.
4A. Monitoring Users: Individuals who are accountable to or are the users monitor the appropriation and provision levels of the users.
4B. Monitoring the Resource: Individuals who are accountable to or are the users monitor the condition of the resource.
5. Graduated Sanctions: Sanctions for rule violations start very low but become stronger if a user repeatedly violates a rule.
6. Conflict Resolution Mechanisms: Rapid, low-cost, local arenas exist for resolving conflicts among users or with officials.
7. Minimal Recognition of Rights: The rights of local users to make their own rules are recognized by the government.
8. Nested Enterprises: When a common-pool resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers.

Even though Ross and Martínez-Santos (2010) adapted these design principles significantly so as to be able to pose answerable questions in a groundwater setting, they could still only find two of the (modified) design principles that had been met. The modified design principles that were met were:

- Rights to harvest the resource well defined.
- Resource users have long-term tenure rights to the resource.

These two rules are so modified from Ostrom's design principles that it seems more reasonable to regard them as new rules, rather than adaptions of existing rules. It is suggested that if Ross and Martínez-Santos (2010) had adhered more closely to Ostrom's design rules it is possible that they would have had to conclude that none of these design principles had been met.

Common difficulties experienced in Spain and Australia in establishing robust and sustainable groundwater governance (Ross and Martínez-Santos, 2010) include:

- Perceived insufficient knowledge of groundwater yields and groundwater-surface water and groundwater-ecosystem interactions = Ostrom's design principle 1B [Clear Resource Boundaries] not met?
- Establishment of appropriate systems of groundwater ownership and/or entitlement have not kept pace with the development of groundwater = Ostrom's design principle 2A [Congruence with local conditions] not met?
- Enforcement of centrally determined controls cause strong resistance = Ostrom's design principle 7 ignored by central government [The rights of local users to make their own rules are recognized by the government].
- Lack of trust. Trust is not a specific design principle, but a key ingredient underpinning Ostrom's thinking.
- Lack of benefits = Ostrom design principle 2B. Appropriation and Provision: Appropriation rules are congruent with provision rules; the distribution of costs is proportional to the distribution of benefits.

The congruence between Ostrom's design principles and what Ross and Martínez-Santos see as missing or difficult to realise in the Australian and Spanish cases suggests that a deliberate and planned attempt to introduce these design principles in a groundwater governance setting could well bear fruit. Lopez-Gunn and Cortina (2006) suggest the way in which high-level authorities oversee the devolution to self-management should be very pragmatic and gradual.

3.5.3.10 China – General

The general situation regarding groundwater governance in China appears to be not dissimilar to that in countries like South Africa, Mexico and Spain, with new direct regulation laws being made, new policies applied, but with very little net effect (Wang et al., 2009).

China is one of the highest global users of groundwater, along with countries like India, the United States, and Pakistan. Whether China's groundwater use exceeds groundwater availability has been subject to much debate. The general consensus appears to be that it is only in the North China Plains where there are serious problems (Wang et al., 2007), (Huang et al., 2009), (Wang et al., 2009). China's Ministry of Water Resources has put some numerical perspective on the crisis. The Ministry estimated that groundwater use exceeded supply by some 9 km^3 in the late 1990s (Wang et al., 2009).

The nature and extent of this crisis has, however, been disputed. Wang et al. (2009) for example, argue that most of the dire assessments and predictions are not based on reliable data. For most of the north China plains, water level declines from 1995 to 2004 have been insignificant, since 51% of the communities report either water level rises, no water level falls, or water table declines of less than 0.25 m/year. However, as Wang et al. (2009) point out, one should guard against playing down the water problems in the north China plains, since even if 'only' some 10% of the communities are experiencing problems with irrigating from groundwater, this is not insignificant. Ten per cent of the community amounts to some 50 million people.

Although the nature and extent of north China's water crisis may be disputed, there appears to be little dispute that the state government's response to the crisis has been largely ineffective (Wang et al., 2009). Although government officials have made efforts to issue laws, regulations and policies, including the 2002 revision to China's National Water Law, that made all rights to groundwater the property of the state, the implementation of these regulatory measures has been very weak. So weak, that groundwater resources are regarded by Wang et al. (2009) as essentially unregulated in most communities. For example Wang et al.'s (2009) survey showed that less than 10% of well owners obtained a drilling permit, although permits are now compulsory. Only 5% of community leaders believed that well spacing should be considered even though this is also compulsory. No water extraction charges are ever imposed and no quantity limits are put on well owners.

3.5.3.11 China (Minquin County)

As with most countries, at least one anomalous example of good groundwater governance can be found amongst the overwhelming evidence of ineffective governance. In China's case Minquin County provides such an example (Aarnoudse et al., 2012). Superficially this might be ascribed to a case of 'direct regulation' actually working, but on closer inspection its success appears to be due to the fact that there was a strong, pre-existing local institution that was prepared to carry out the 'direct regulation' from higher authorities, and were given considerable leeway in how they implemented the rules issued to them. [Direct groundwater regulation refers to, for example, borehole registration, the issuing or permits to use groundwater by a higher authority.]

Aarnoudse et al. (2012) argue water policy reform in China that lead to the formation of WUAs, did not lead to local level participatory management. Instead it created effective linkages between different levels of institutions, thereby enabling the implementation of direct regulation measures formulated at county level, and implemented at the sub-village level.

Minquin County has experienced declining water levels from approximately 10 m in the 1970s to approximately 30-40 m below surface today as a result of the use of motorized boreholes for irrigating crops. Initially, this received little attention from the various tiers of government, but since 2001 Minquin's growing water scarcity attracted attention from both national and provincial government leading to the Shiyang River Basin Management Plan being approved in 2007 (Wang et al., 2009). A variety of regulation measures were available, but only those mentioned by the farmers in interviews with Aarnoudse et al. (2012) were mentioned in the study. The

two measures effectively implemented were the closure of wells and a per capita water use restriction. These measures appear to have been effective because official records record that a total of 3000 wells were closed in Minquin between 2007 and 2010, and water quotas determined and enforced by the WUAs.

Aarnoudse et al. (2012) ascribe the success of these measures to the pre-existence of existing institutions with responsibilities for water matters right down to the farm level, and the ability to transplant groundwater reduction strategies on village committee and farmer's groups that were previously concerned primarily with exploiting water. This obviously depended on the village committee and farmers groups being amenable to state control. Although WUAs were created under China's legislation, and tasked with reducing groundwater use, these WUAs were essentially the existing village committee being asked to, and reimbursed for, doing an additional job. It would also appear (this report's comments) that appropriate delegation of authority also helped the process. For example, although the higher level Irrigation District Bureau might decide how many wells needed to be closed down, it was the WUA that had to decide where and which wells to close.

Aarnoudse et al. (2012) might argue that they have shown that direct regulation can work. However, this report would argue that what they have shown is that when there are effective existing local community governance institutions in place, then sometimes these local institutions can give effect to top-down instructions. This is very different from a high-level government institution, by itself, effectively and directly imposing governance rules on end-users. Thus Aarnoudse et al. (2012) have not proven that direct regulation can work.

3.5.3.12 India (Andhra Pradesh)

As opposed to attempted 'direct' regulation, where rules are determined by and policed by an external entity, or where groundwater governance is primarily locally driven, with little or no support from higher authorities, the Andhra Pradesh experiment provides another 'hybrid' approach. The Andhra Pradesh experiment attempted to foster voluntary self-regulation by encouraging farmers to collect water data and make collective water use decisions themselves (Garduño et al., 2009). Higher authorities reasoned that by demystifying the science of hydrology through training (data collection of rainfall, well charge rates, groundwater levels), analysis, and participatory crop water budgeting, farmers would inevitably carry out sustainable management of the resource.

Nine partner NGOs (FAO, 2010; Verma et al., 2012) implemented the experiment across seven drought-prone districts of Andhra Pradesh. The implementing agencies regarded the experiment as a major success (FAO, 2008; FAO, 2010) and Garduño et al. (2009) even declared that the experiment ***"may be the first example globally of large-scale successes in groundwater management by communities."***

However, a survey carried out by Reddy and Reddy (2012) to re-appraise the success or otherwise of the experiment painted a less flattering picture. The overall impression gained by Reddy and Reddy (2012) was that in most cases the practices initiated by the NGOs had been abandoned once the NGOs left. The following graph (Fig. 1) summarizes the change in practices:

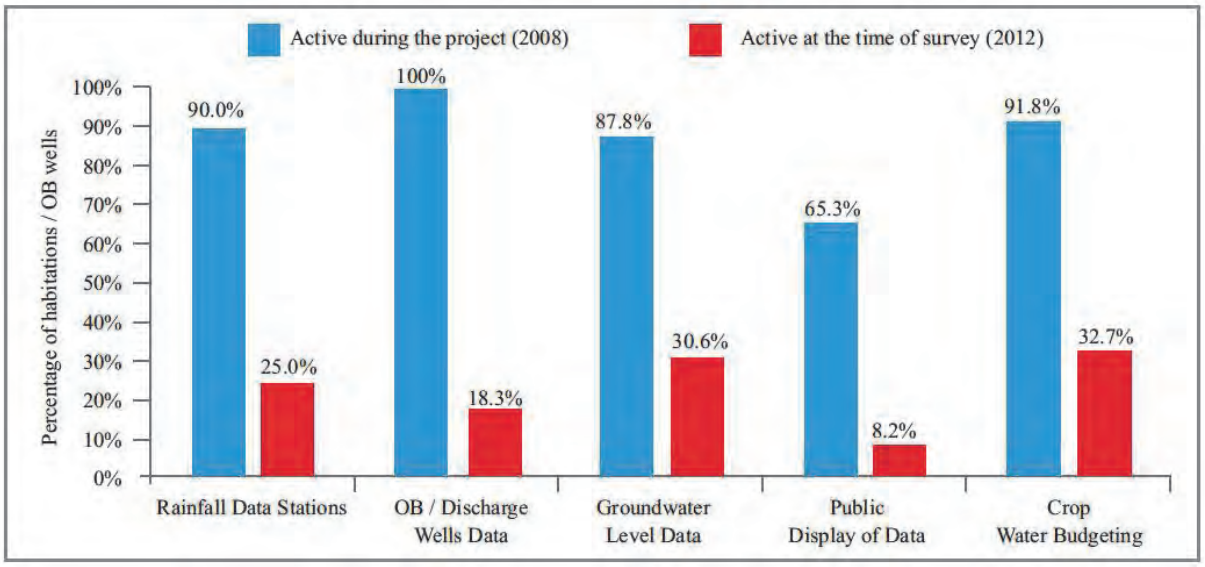


Figure 1. Andhra Pradesh groundwater governance activity (Reddy and Reddy, 2012)

Based on comprehensive interviews Reddy and Reddy (2012) observed that reasons for the discontinuation of practices included:

- Monitoring equipment had been rendered useless or needed repairs.
- Farmers preferred their own, traditional, heuristics that they had developed over the years for managing their groundwater and crops, rather than the hydrological approach advocated by the NGOs.
- Farmers felt obliged to comply with the NGO hydrological practices, but once the NGOs had gone they no longer felt obligated, and returned to traditional practices.
- Crop water budgeting was not supported by regulations on water and electricity.
- The collective in charge of crop water budgeting had no authority to implement its decisions, and without the NGOs to provide 'social pressure', implementation of the rules broke down.
- Farmers reported an inability to do crop water budgeting themselves when the NGOs had left since it had been mainly done by NGO staff.
- Few farmers were willing to fund crop budgeting workshops themselves once the NGOs and their funding had left.

However, there were some exceptions to the general trend (Reddy and Reddy, 2012). One exception involved a community organization such as a credit cooperative that pre-dated the arrival of the NGOs, taking on groundwater management duties, and continuing with these duties once the NGOs had left. Other exceptional cases seemed to be the result of continued NGO support after the NGO project had officially ended.

Reddy and Reddy (2012) make an interesting comparison between Ostrom's design principles (Ostrom, 2001) for sustainable governance of common-pool resources, and whether these are applied in the Andhra Pradesh area. They conclude several rules are in place for most cases, but the following rules are almost invariably absent:

- Ensure universal legitimacy of rules
- Graduated sanctions for violators
- Accessible, low-cost means for dispute resolution

In the absence of these rules, informal authority and social sanctions were the only remaining tools. It seems clear that either the NGOs and/or strong, local community organizations were – on the whole – sufficient to compensate for the lacking Ostrom Design Principles (ODP). However, with neither a NGO, nor a strong community organization as support, the governance had a high probability of being unsustainable.

It is suggested that it was not the provision of the hydrological information support that was the key to making the Andhra Pradesh experiment work, albeit for a limited period of time, but the sanctions and legitimacy the NGOs helped provide.

Although the Andhra Pradesh experiment was not the unmitigated success described by Garduño et al. (2009), it was hardly an unmitigated failure either. In terms of a 'successful intervention' test for good governance it was a success. Severe groundwater over-exploitation was arrested. In 93% of the Hydrological Units the groundwater overdraft was either consistently or intermittently reduced for the three-year period of the study (Garduño et al., 2009), and only 7% of the Hydrological Units showed an increase in the groundwater overdraft.

If only 10-15% of these successful interventions persisted when the NGO support stopped, this 10-15% success rate compares favourably with a close to 0% success rate in most other parts of the world. Clearly there is much of value to be learnt from the Andhra Pradesh experiment. One of the most important lessons is that in a country with millions of wells and millions of groundwater users, making 'command-and-control' type direct regulation of groundwater use seems impossible. However, it is still possible to regulate groundwater using a community-based, participatory approach. Furthermore this regulation was done without any net reduction in farmer's incomes, and without appealing to groundwater users to make any sacrifices, but using business models and farming techniques. This appears very encouraging. Since the Andhra Pradesh experiment did contain a degree of success, it would seem prudent to build on those successes, rather than dismiss it as a failure.

3.5.3.13 Adaptive groundwater governance versus ecosystem services

Knüppe (2012) compared the relationship between the provision of groundwater associated ecosystem services (GWaESs) and the level of groundwater governance in case studies in Spain (Upper Guadiana Basin), South Africa (Sandveld) and Germany (Spree Basin). The main objective of the study was to determine whether there was any relationship between adaptive groundwater governance regimes and the state of GWaESs, and more specifically at whether institutions were responsive and effective.

In the extensive research done for this report, this is the only groundwater governance study found in the academic literature that has followed a formal diagnostic framework. The approach used was the 'Management and Transition Framework' (MTF) developed at the University of Osnabrück (Pahl-Wostl et al., 2010). The analytical framework was used to explore the complex system linkages

and feedbacks between governance regimes, GWaESs, human well-being and the overall state of the ecosystem. The MTF is described in more detail in section 8.2.2.4. The framework ensures that all the case studies are represented in a standardized and comparable way.

The research was based on the assumption that the sustainable management of GWaESs requires adaptive governance regimes characterized by ecological understanding and learning environments that adjust their responses in order to deal with change and uncertainty. The analytical focus was placed on investigating vertical (hierarchies) and horizontal (sectors) integration structures assumed to be crucial for adaptive governance, and a historical time frame of 20 years was chosen for the study.

Knüppe (2012) found that:

- The general awareness and significance of GWaESs supporting human well-being increased where vertical and horizontal integration structures are in place.
- A high degree of integration in management activities and the involvement of stakeholders do not necessarily lead to a direct improvement in GWaESs.
- Institutional response is at an early stage in terms of integrating the perspectives of GWaESs.
- The presence of well-crafted governance institutions does not automatically mean that there will be successful interventions to bring about social, economic or ecological sustainability.
- Changing governance structures towards more adaptive and sustainable management structures requires a break from traditional structures and could take decades rather than years to implement.

3.5.4 CONCLUSIONS

3.5.4.1 Broad Categories of Groundwater Governance

This categorization is based on broad processes of groundwater governance rather than on groundwater's legal status. The broad categories of processes identified are:

1) **Private (individual rights***)* – groundwater users have the right to abstract as much groundwater as they like on the land they own, subject to certain conditions
2) **Local** – groundwater users recognize they are abstracting from a shared, local resource and have rules in place to protect the resource and its users, independent of any higher institutions, or by lobbying higher institutions to intervene
3) **National** – the national/state government attempts to regulate that use via issuing licenses or permits to individual users
4) **National and Local** – a higher/national institution makes the rules and a local institution such as a WUA is expected to implement those rules

3.5.4.2 Major Groundwater Governance Tools used

'Governance tools' includes, for example, licenses and permits and other means to regulate groundwater use. The list below is not exhaustive, but merely seeks to show that the issuing of licenses or permits by a national or regional or state authority is not the only management tool available. Some of the groundwater governance tools encountered were:

- Well spacing – no new wells within a certain distance of an existing well. This distance was often increased when the well or spring was a source of drinking water for a community and was the only source of that drinking water.
- Maximum drilling depths.
- Bans on types of well – e.g. only hand-dug well and no boreholes.
- Restrictions on the types of crops grown.
- Number of hours per week that groundwater could be pumped from a borehole.
- An allocated quantity per annum.
- A certain percentage of the resource.

It was not possible to rank these tools from the most used to the least used because this is a limited, exploratory review. However, it seems clear that allocating quantities of groundwater per annum was not the tool most widely used. There is a need to look at a broader suite of tools if groundwater governance is to be successfully implemented.

3.5.4.3 Overall Success Rates for Groundwater Governance

As mentioned before, this is an exploratory review and not a comprehensive review, and it is therefore not realistic to quantify success rates for groundwater governance. Attempting to reach agreement on what is meant by 'successful' groundwater governance is also problematic. If 'success' is defined as an intervention that was successfully made to address a specific issue, then the impression created from the literature is that this might have occurred in only 1% or less of the areas where groundwater is used. If 'success' is defined as having a sustainable process in place that will always be able to deal with issues, then the success rate is probably closer to 0%.

A negative pattern that emerges in the literature is that progressive legislation does not seem to make a significant difference to groundwater governance. South Africa, Spain, Mexico, California and China all have progressive laws to enable groundwater governance. However, these progressive laws do not seem to have made a significant impact on the effectiveness of groundwater governance in these areas.

It is difficult to establish which of the broad categories of groundwater governance is more or less desirable because all are associated with examples of failure. It could be argued that if governance is purely 'national' or purely 'private' the chances of successful groundwater governance, however it is defined, are exceedingly low. Success rates for 'local' and 'national and local' are probably better than for 'national' or 'private', but remain low.

To further 'muddy' the debate, the broad patterns summarized in the previous paragraph are prone to be contradicted by anomalies. For example in the USA, where individual rights in general (and not only with regard to water rights) are firmly established and defended, it is still possible to find an example where private rights have been severely curtailed. For example in the Walnut Creek Intensive Groundwater Use Control Area farmers have been forced to reduce groundwater use, and flow meters are compulsory. This underscores that there may not be any absolute panaceas. It is possible to effect good groundwater governance even in countries where private rights are enshrined. Transferring private rights to public rights is not a panacea. In effect, the Walnut Creek Control Area is not unlike a Government Groundwater Control Area in pre-democratic South Africa. In principle it was possible to control groundwater use in Control Areas in pre-democratic South Africa even though groundwater was deemed private on a national basis. These limited attempts to control groundwater use in limited areas were not a resounding success. Since control areas did not prove to be a success in limited areas, it seems somewhat paradoxical that the authorities felt that control could or should be expanded across the entire country.

The only positive, general rule that emerged from the literature review is the need for local stakeholder support for groundwater governance – or at least a begrudging acceptance of the need for stakeholder support. There was a consensus across the literature (albeit it not universal), that there is need for communication, cooperation, sharing of information and data, and initiative at the local scale. Without this community support, no amount of progressive legislation or scientific studies appears to be effective.

In general, local stakeholder support for groundwater governance translates into the use of governance rules using indicators that are *simple, easily monitored and easily enforced*. Well spacing is easily monitored and easily enforced if there is sufficient social pressure.

3.5.4.4 General Rules that could be imported to the South African Situation

General rules were difficult to find. For each 'rule' that a researcher associated with good groundwater governance, it was usually possible to find many cases where groundwater governance was possible without this rule, and it was usually possible to find many cases where this rule did not lead to good groundwater governance.

Perhaps the closest to a general rule that could be found was that the acceptance, cooperation, initiative and communication at the local level are crucial. At the local level, clear indicators that are easily understood and easily used to monitor and enforce groundwater use decisions are far more important than complex scientific investigations and parameters.

Perhaps a useful second 'rule' at this stage would be to accept the limitations as to what national and regional governments and even CMAs can usefully contribute to groundwater governance. These higher-level institutions need to be *supporting* rather than i*mplementing* agencies. Thus, higher-level institutions should be supporting the creation of local groundwater governance institutions and supporting their decision-making and enforcing powers. If higher institutions adopted this 'rule,

then they would need to re-think their role in groundwater governance and make the paradigm shift from being an agent of control to one of support.

Such an approach would help alleviate the 'tension' between the *objectives* of governance and the *process* of governance. Tension would be alleviated because higher institutions would help create the local government institution *process* while the local institution would decide on local *objectives* (albeit within the confines of – some – broad parameters set at a higher level).

The World Bank's 20 point checklist, as used in the South African Case study (Pietersen et al., 2011), is in effect, expert opinion, rather than evidence-based rules. This checklist is useful for analysis and comparison, but should be used with caution for institutional design purposes until more supporting empirical evidence is available.

The Ostrom Design Principles (ODP) were the only evidence-based rules that were found. They were originally formulated from Common Pool Resource (CPR) governance studies rather than from groundwater studies. However, they are transferrable to groundwater, since groundwater is, or can be treated as, a CPR. These evidence-based rules could be 'translated' specifically for groundwater and used in groundwater governance.

The following assumption should be avoided; that if the right governance environment is created, and the right tools are provided, that these 'ingredients' will somehow coalesce of their own accord into a good groundwater governance system. This is unlikely. The processes to create the system need to be driven by individuals or by institutions.

3.5.4.5 Methodologies for designing good groundwater governance

Most of the case studies were of the informal "contrast and compare" nature. While this type of study works well for exploratory studies, it is not well suited to a more formal analysis or design of groundwater governance institutions. The only formal framework located for the analysis and design of groundwater governance was the Management and Transition Framework (MTF) employed by Knüppe (2012). However this is a University of Osnabrück creation, and appears to have only been used by that university. The MTF may be difficult for those outside of the University of Osnabrück, to understand or implement.

3.6 Discussion

3.6.1 FEEDBACK LOOP PERSPECTIVE

The preceding case studies were carried out at variety of scales and homed in on a variety of issues. This made it difficult to categorize or compare these studies, and difficult to conceptualize the core governance process involved. In order to overcome these difficulties the feedback loop concept is introduced so that there is a simple, easily understood, and common 'language' (or common concept) that can be utilized in an attempt to analyse and compare case studies.

A feedback loop is the path that leads from the output of a mechanism, process, or signal, carrying part of the output back to the input so as to modify the nature of

that mechanism, process or signal. Feeding back part of the output so as to increase the input is known as a positive feedback loop. Feeding back part of the input so as to decrease the input is known as a negative feedback loop.

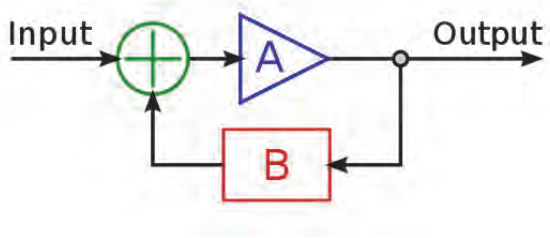


Figure 2. Simple Feedback Loop

A simple example of a feedback loop is the thermostat on an air conditioner. If the temperature exceeds, or goes below, a certain predetermined temperature, the thermostat informs the air conditioner to cool or heat the room accordingly using a negative feedback loop.

According to Levin (1999) "***tight reward and punishment loops are essential for any adaptive change.***" These tight feedback loops occur when individuals interact at the local scale, and within realistic time frames. Then individuals feel the costs and benefits of their actions directly. The broader the scale, whether in time or space, the looser the feedback loop, and the less motivation there is to make changes. An action that causes negative impacts in our own home in the next 24 hours is likely to be avoided. An action that might cause damage to another continent in a 100 years' time is less likely to be cause for concern. Few people would want to dispose of trash in their own homes forever. But if another continent indirectly disposes of our waste by doing the mining and manufacturing that produces the consumer products we buy, few of us would even think of this as an issue.

Thus, making the payoffs for good behaviour nearer and clearer increases the chances of success. Feedback loops need to be closed so that the consequences of individual or corporate behaviours are directly felt by those individuals or corporations.

Pollard et al. (2011), in their guide to complexity theory and systems thinking, provide examples of how diagrams of feedback loops (Fig. 3) can be useful in explaining management structures and linkages.

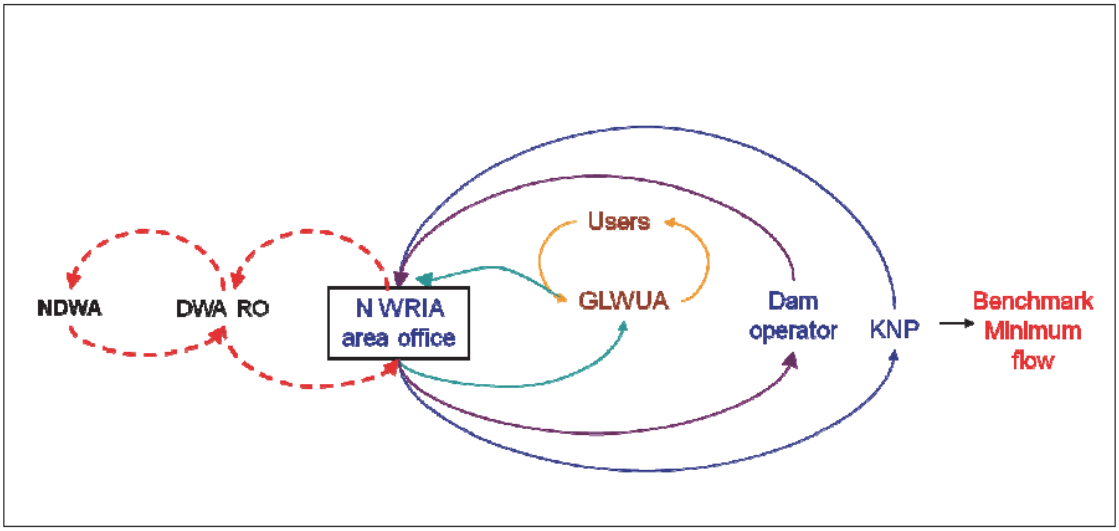


Figure 3. Functional feedback loops in the Letaba Catchment (Pollard and Du Toit, 2011)

[NWRIA = National Water Resources Infrastructure Agency, KNP = Kruger National Park, GLWUA = Groot Letaba Water User Association]

According to Pollard and Du Toit (2011) the key elements necessary for feedback loops in their WRC study were:

- The requirements of the law (supportive legal and institutional milieu (the Reserve).
- The availability of benchmarks against which to monitor (the IFR/ Reserve).
- The presence of a 'watchdog' (although intermittent).
- The buy-in of users (also assume that they are getting a share).
- Accountable leadership together with effective governance.
- The responsiveness of the manager and users.
- The ability to act (staff, skills, capacity, tenable Reserve statements, infrastructure and so on).
- The ability to self-regulate (bailiffs, incentives to comply, authority to act).
- The ability to self-organize.
- The ability to reflect and learn.

Although these elements were formed for a specific study they appear to have considerable overlap with the ODP. This overlap suggests that further investigation as to whether they can be used in a much broader context, is warranted.

3.6.2 GROUNDWATER GOVERNANCE VERSUS FEEDBACK LOOPS

Mukherji and Shah (2005) seem to be moving towards the concept of feedback loops, when they point out that one of the main problems in groundwater governance is the misallocation of roles. For example central and regional governments may be given roles that are beyond their human and financial capacity. At the same time, farmers and other stakeholders are expected to participate in

aquifer management when their immediate interests lie in not participating. It stands to reason that there is little motivation for a farmer to become involved with a WUA, when the main function of that WUA is to reduce the amount of groundwater abstracted and therefore reduce the farmer's profits. Although Mukherji and Shah (2005) do not explicitly state this, the logical consequence of their observations is that an absence of short, direct feedback loops is hampering groundwater governance.

Mukherji and Shah (2005) also make the interesting observation that being a wealthy country (e.g. the USA) does not, in itself, seem to confer on that country any significant benefits regarding groundwater governance. When groundwater plays a relatively small part of a country's economy, the implementation of groundwater governance seems no easier than in the example above. In this a situation (where groundwater has a small role) groundwater users would be expected to have little influence over groundwater governance, since the damage to the economy would be only marginal if groundwater abstractions were reduced.

However, if a community depends on groundwater for their drinking water, that community will almost certainly intervene and take steps to protect their water supply. In some areas in Yemen this is achieved using groundwater management based on well spacing as decreed by a centuries old prophet. This may not seem like advanced hydrogeological science, but for the most part, this 'method' is effective because the well-spacing rule is enforced, either by peer-pressure, or by appeal to state authorities, or other means. In fact it could be speculated that if strong enough control measures were in place, groundwater could well be governed using trial and error and without science. It could be further speculated that local 'institutional wealth' (in the case of strong, functioning local institutions) is far more important than financial wealth or 'scientific wealth' in determining the success or failure of local groundwater governance in a given country.

From the feedback loop perspective this suggests that local motivation and enforcement via a feedback loop, is far more important than the financial and scientific resources available to a country, when good groundwater governance is needed.

In the case of the USA High Plains Aquifer it is doubtful whether local management is a panacea. The most likely tight feedback loop in this case would be food policies and agriculture strategies from Federal Government, specifically financial incentives to High Plains farmers to adopt sustainable agricultural practices in order to protect national food security. But perhaps the most important lesson from the High Plains case is to reinforce the observation of Mukherji and Shah (2005) that different areas will require a different mix of groundwater management tools.

It would seem that it is the tightness of the feedback loop that determines the effectiveness of groundwater governance, not whether the governance is national, regional or local. A national change in legislation that brings significant financial rewards to some local farmers will (most likely) bring about those changes since it does form a tight feedback loop. Conversely, over-abstraction that may cause the depletion of a farmer's groundwater supplies in 5 years' time, or maybe 50 years

time is not a tight feedback loop. For a commercial farmer a feedback loop would be 'tight' if it involved immediate financial gain.

Permanence or 'sustainability are another aspect of the feedback loop that warrant examination. It would appear comparatively easy to create an operational feedback loop in the short-term – for example DWA's intervention in the Tosca-Molopo area. However, for governance to qualify as effective, it has to be sustainable. Unfortunately, it is unlikely that even in this case, that the feedback loop will be more than a temporary, once-off phenomenon, with little long-term benefits.

The case studies outlined in this report have predominantly focused on the reservoir yield of an aquifer and how to preserve that yield. In some cases preserving stream flow has been considered. The 'non-consumptive' use of water for ecosystem health was rarely considered. South Africa can be given credit for including environmental issues in its Water Act (RSA, 1998). Unfortunately, to date, it has been the over-abstraction of a CPR that generates the most attention rather than actual or potential damage to ecosystems. As Mukherji and Shah (2005) point out: ***"while making a [water] law is not very difficult, enforcing one is a challenge."*** This suggests that while it may be difficult to generate groundwater governance institutions that will deal with over-abstraction and pollution of the resource itself, it is going to be even more difficult to engender a groundwater governance institution that will effectively deal with impacts to associated ecosystems. Presumably there would have to be 'agents' representing the various ecosystems in the local governance institution so that the feedback loop between groundwater and ecosystems can be satisfactorily addressed.

There is evidence that the dichotomy of interest between self-interest (consumptive use) and public interest (non-consumptive use) does not seem to be a major issue once local governance becomes reasonably effective. For example, one might expect a WUA to be mainly concerned with protecting the individual interests of its members, but this has not been the case in, for example, the Catalana GWUA (López-Gunn and Cortina, 2006) where the WUA has protected public interest issues as well. A possible explanation for a WUA tackling broader issues than its own direct self-interest may be found in the thinking of Levin (1999). Levin observes that the mere fact that some kind of local feedback has been created very often leads to a tightening of this loop because the status and satisfaction from the benefits of this loop leads local stakeholders to apply the processes with more vigour and enthusiasm.

Whether it is dealing with impacts to ecosystems, or to consumptive users, with or without the help of a WUA, there are no blueprints that will work everywhere. A groundwater governance system that has worked in one country could well increase the anarchy of groundwater management in another country. For example, López-Gunn and Cortina (2006) assert that a healthy, functioning higher-level water authority is a prerequisite for the effective functioning of local governance. However, many examples can be found where effective local groundwater governance arose despite poor governance from regional or national water authorities, and even in some cases where no higher-level governance actually existed.

The fact that examples of effective groundwater governance are so few, and the fact that there are no blueprints for effective groundwater governance, strongly suggests that good groundwater governance is as much the result of a fortuitous coming together of key components, rather than the logical outcome of good planning and design. It is as if the key components of a strong feedback loop momentarily constellated, and helped create a positive outcome. Because this fortuitous constellation of components is so tenuous, they could disintegrate just as easily as they coalesced. The few examples of good governance may be short-lived and be replaced by poor groundwater governance, as has happened with the Andhra Pradesh experiment. To prevent this negative outcome and to optimise levels of good groundwater governance a more deliberate, thoughtful, and sustained programme is required.

With so little empirical evidence of good groundwater governance and with few proven and effective groundwater governance interventions, a clear and methodical solution to poor groundwater governance is impossible to 'pin down'. From the feedback loop perspective, a somewhat vague recommendation can be made; 'strengthen the feedback loop'. Management is, essentially, about the generation and implementation of a plan, the monitoring of the impacts of that plan, and the adjustment of the plan according to the monitored impacts. It can thus be argued that a simple, tight governance feedback loop is needed – one that can respond to the complex feedback loops of a complex system.

It is highly likely that for every example of a groundwater management tool that has working in a given setting, there are numerous examples where it has not worked. It is possible that an opposing approach was more effective. The conclusion that can be drawn from this is that it is impossible to be prescriptive. Each case will need to build its own management system, construct its own management feedback loop, build on strengths, and address weaknesses. This would need to be implemented one step at a time, testing out each component of the management system, until an optimal system is found.

3.6.3 THE 'TRAGEDY OF THE COMMONS' – IS IT INEVITABLE?

Even when the definition of good groundwater governance is made very narrow (e.g. down to a simple decision to make and then implement an intervention), it is difficult to identify any good examples of groundwater governance. From this, it would be easy to draw the conclusion that good groundwater governance is not possible, and that Hardin's gloomy scenario of common-pool resources being locked into a downward spiral is somehow the inevitable fate for groundwater. But is this conclusion correct?

The work of Ostrom (1990, 2001, 2005, 2009a) and others has shown that, by analysing numerous examples where diverse common-pool resources are involved, and developing a 'common language' to describe different scenarios from diverse disciplines, many useful general insights can be drawn. These insights could be applied to groundwater governance, specifically:

- The 'Tragedy of the Commons' remains possible but is not inevitable, and occurs less often than one might think.

- Local governance in the form of self-regulation is certainly possible, but by no means inevitable, and occurs surprisingly more often than one might think.

3.6.4 CONCLUDING REMARKS

Taking into account and reflecting on the evidence collected by this report and taking into account the project authors' experience of groundwater governance institutions, a reasonable summary of the 'facts' would be:

- The overall problem is that groundwater governance is dealing with a Complex Adaptive System (CAS).
- Some groundwater scientists, and many institutional groundwater managers, appear to unaware of CASs.
- Many researchers with knowledge of CAS do not appear to see groundwater as a CAS research area.
- Therefore the challenge of practically applying CAS wisdom and management approaches to the groundwater governance system is daunting.
- Local governance appears to be a prerequisite for good groundwater governance. Top-down governance approaches inevitably fail if there is no strong local governance system in place. On the other hand, there are plenty of examples of effective local groundwater governance, with or without the support of a top-down system. Thus local governance is the pre-requisite.
- While local governance is a prerequisite for effective groundwater governance, it does not guarantee effective governance. Local groundwater governance appears to fail far more often than it succeeds.
- Rules or blueprints that will guarantee effective local groundwater governance have not been established.
- The ODP have been shown to be a good guide to the sustainability of the governance system for a Common Pool Resource (CPR).
- Since groundwater can be regarded as a common pool resource, there would appear to be wisdom in applying the ODP to the groundwater governance field.

4 METHODOLOGY

4.1 Introduction

The overall purpose of this project is to identify key interventions to improve groundwater governance in South Africa. The preceding chapters have introduced:

- Debates related to the definition of groundwater governance.
- Expert opinion on how to improve groundwater governance.
- Case studies of groundwater governance in action.
- Methodologies for analysing groundwater governance.

These introductory chapters have shown that the implementation of groundwater governance and groundwater governance research is still in its infancy. Examples of good groundwater governance are anomalous – there is little that can be directly learnt or exported from them. Methodologies to analyse and design groundwater governance systems have been barely tested. Therefore there is a need to do more research on methodologies to analyse and design groundwater systems before resorting to checklists to solve the South African groundwater governance issues.

Therefore, the remainder of this project/report will be as much about assessing the methodologies to analyse and design groundwater governance institutions as it is about an analysis of existing institutions. Before specific recommendations are made regarding methodologies, the methodologies under consideration will be briefly reviewed.

4.2 Methodologies Considered

4.2.1 COMPARE AND/OR DISCUSS CASE STUDIES

This was the most popular method of analysis. Since groundwater governance and the analysis of groundwater governance is still in its infancy, there is a need and room for exploratory research (such as this report). This open-ended mode of inquiry allows for insights and discoveries that more systematic and constrained methodologies might miss. However this approach has its drawbacks, including:

- Lack of a common 'language' – different investigations may use different names for the same process, thus leading to confusion.
- Lack of systematic approach means one study could ignore something that was considered crucial in another.
- In many groundwater governance studies it is not clear whether the insights presented flow logically from the data studied, or whether they are just personal ruminations from the investigators regarding groundwater governance in general.
- It appears to have very limited value in establishing general patterns. One study might find, or opine, for example, that 'information and education' programmes lead to the good groundwater governance system in their case study and then proclaim this as a panacea. However, other case studies would show that despite

information and education programmes there was still ineffective groundwater governance. Yet other studies might find good groundwater governance without any information and education programmes in place. To further confuse matters, other studies might not even look at information and education programmes.

The 'contrast and compare' approach is useful for introductory inquiries into general rules or general processes for deciding rules about groundwater governance (to extrapolate to South Africa). However, this approach is very limited when trying to design or specify key requirements of a governance system.

4.2.2 WORLD BANK CHECK LIST OF 20 BENCHMARKING CRITERIA

This was the approach used in the South African case study (Pietersen et al., 2011), and was used in other GEF regional case studies.

The advantage of this approach is that the criteria listed are quite specific, thus allowing systematic investigations and comparisons between one country or region and another. However, there is simply no evidence available that by having some or all of the criteria in place that groundwater governance will be created or will be sustained**.** This assertion may be disputed. However this assertion can be supported in the following way: 1. Groundwater governance and groundwater governance research are still in their infancy. 2. The World Bank benchmarking criteria have not been adequately tested in empirical situations. 3. Investigators such as Wester et al. query whether any examples of good groundwater governance exist anywhere. 4. The literature review for this report has found that few good examples of groundwater governance exist. Although Pietersen (2014) has pointed out that the World Bank benchmarking criteria are based on the practical experience of two experts, Stephen Foster and Hector Garduño, there is little academic literature available to substantiate the benchmarking criteria in 'action'. For this reason it seems reasonable to assume that the benchmarking criteria are *currently* expert opinion and not empirically established rules. There is nothing wrong with expert opinion, especially when empirical rules are not available. However the two forms of knowledge should not be conflated. Empirical rules will be able to predict future events with a higher degree of certainty that expert knowledge.

Although the benchmarking criteria may well play a small or significant role in groundwater governance, they cannot, of their own accord, make good groundwater 'materialize'. To 'test' this argument the first item on the list of benchmarking criteria will be examined; hydrogeological maps. Knowing the boundaries of a resource may be useful in the process of good groundwater governance but is it essential? The boundaries can be established in different ways (technical reports, expert opinion, trial and error monitoring). However, they may or may not be critical to the process. In South Africa there is little evidence to show that the 10-year presence of hydrogeological maps has made a significant contribution to good groundwater governance because governance remains weak. In contrast, Yemen has some examples of good groundwater governance but has managed this without hydrogeological maps and possibly without any expert input from hydrogeologists (Taher et al., 2012).

The World Bank's checklist takes a 'hydrocratic' perspective of the groundwater governance process. The list favours issues that technical experts would like to see applied to groundwater governance. This perspective may be correct but until the criteria have been rigorously and empirically tested across different scenarios and by a variety of researchers, this remains conjecture.

4.2.3 OSTROM DESIGN PRINCIPLES

Since empirically tested groundwater governance rules do not yet exist, it is necessary to explore areas outside of the groundwater field. Rules applied to Common Pool Resources (CPR) have been empirically tested. Simply defined, a CPR is one for which the right to use is shared with others in a way that one person's use subtracts from another's use. Since aquifers can straddle farm, regional and national boundaries, and one person's use subtracts from another's use, there is a commonality between CPRs and aquifers.

It can be debated whether groundwater meets all the criteria for a CPR. However, it does meet some crucial criteria or classic dilemmas experienced by CPRs e.g. it can be difficult and costly to exclude other users outside the group from using the resource (Sophocleous, 2010; Llamas and Martínez-Santos, 2005; Giordano et al., 2012). Another important CPR/groundwater dilemma is that no private incentive exists for any user to reduce current consumption so that more will be available for the future. Any user who does so runs the risk that other users will appropriate that reduction for their own benefit.

Ostrom (1990, 2001, 2005, 2009a) looked for specific rules that could serve as prerequisites for sustainable governance for a specific situation. Unfortunately, what Ostrom did find, could not be extrapolated to other situations. Ostrom, therefore, changed the direction of the research and looked for patterns at a broader level of generalisation.

At this broader level the 'Design Principles' (Table 2) began to emerge. Ostrom's heuristic (1990, 2005) is that the more of these design principles that are present, the more likely that local-scale governance will be sustainable. Whether local governance was created through local initiatives, external initiatives or simply 'by accident, the design principles can be applied. In general, the design principles arose through trial and error – almost unwittingly – and the assumption should, therefore, not be made that they were consciously engineered.

In an analysis of 91 studies that utilized the ODP, Cox et al. (2010) found the principles to be robust. Cox et al. (2010) found that criticism of the principles was based more on abstract thinking than on empirical evidence. These 91 studies did not include groundwater. However, the design principles have been used, on occasion, in the analysis of groundwater governance. One example is a study conducted by (Ross and Martínez-Santos, 2010).

Since groundwater shares the majority of CPR characteristics, the ODP may currently be the most appropriate and useful tool for the analysis and design of groundwater governance systems at the local scale.

4.2.4 DIAGNOSTIC APPROACHES

4.2.4.1 Introduction

From the preceding sections it can be seen that an empirical approach to groundwater governance is currently almost impossible. Globally, there is simply not enough data to form realistic hypotheses, and not enough scenarios where hypotheses can be tested. Groundwater governance involves a complex system, adding an additional level of difficulty to its analysis. Thus the diagnostic approach and its suitability for investigating the governance of complex systems will be explored.

Figure 4, taken from Pollard et al. (2011), based on the "Cynefin" model (Snowden, 2002) differentiates between four types of system:

- **Simple** – easy to predict.
- **Complicated** – difficult to predict, but can be predicted with 100% certainty if all the necessary data are available.
- **Complex** – impossible to predict with certainty, but useful patterns may emerge which may facilitate decision-making.
- **Chaotic** – no relationship discernible between cause and effect.

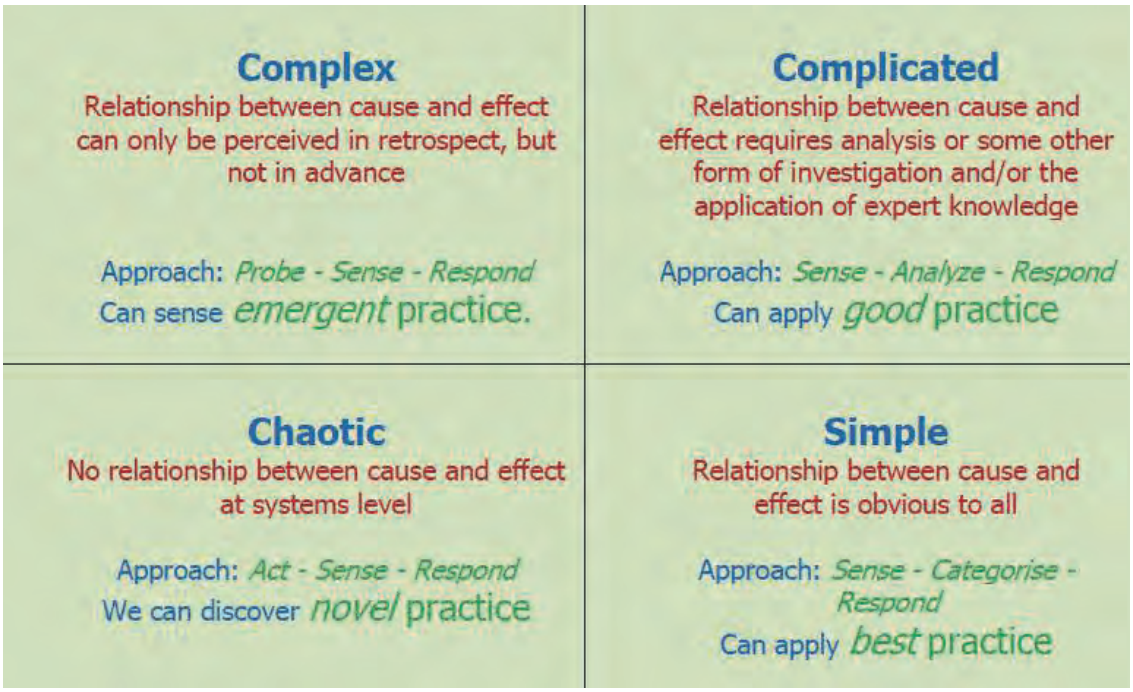


Figure 4. Simple, Complicated, Complex and Chaotic systems (Pollard et al., 2011)

Focusing on complex systems, the following synthesis (Table 3) taken from Pollard et al. (2011) provides more detail on the characteristics of complex systems:

Table 3. Attributes of Complex Systems (Pollard et al., 2011)

Attribute	Example
Socio-ecological systems are **heterogeneous**, **dynamic** and in a state of **flux**. Variability is essential and not a 'management inconvenience or problem'.	Rainfall may vary around an 'average' of 500 mm per year – from 200 mm in a dry year to 800 mm in a wet year. This brings about different effects each year and cumulatively.
Systems have **multiple drivers**, many of which are non-linear in their effects and which operate at different scales. Hence outcomes are usually not entirely predictable. Also some of these drivers may relate to other 'sub-systems' such as a political or global drivers.	For example, a reduction in base flows may reflect increased abstraction, the impacts of a weir and a political decision to expand agriculture, such as biofuels which are seen as a way to improve our foreign exchange
Components of systems are independent and interacting and understanding the linkages is important. In particular **feedback loops** are an important attribute of complex systems.	For example, a reinforcing loop is evident when wetland health improves, causing an increase in the water table which causes a further improvement in wetland health (Pollard et al. 2008c, Cousins et al. 2009). In Tanzania, despite socio-political change,
	persistent feedback loops between monitoring and action have ensured a resilient management system (Tengo and Hammer 2003)
Multiple drivers and feedback loops often mean uncertainty because we **can't predict exact outcomes**, Moreover they can lead to **unexpected outcomes**	For example, the global drive to reduce dependence on fossil fuels (viewed as a favorable position for sustainability) has increased biofuel initiatives which are impacting on water resources and on food availability. This was not anticipated a decade ago.
Complex systems display **lags**	For example, we are unlikely to see immediate benefits from the policy to determine environmental flows because of the complex socio-economic and political arrangements needed to achieve this
Complex systems are not necessarily complicated, in fact, they often only have a **basic set of drivers and responses**.	For example, fire, rainfall and fire management may be the key drivers of a particular system.

Some hydrogeologists appear to believe that a groundwater aquifer is a 'complicated' rather than a 'complex' system. This 'complicated groundwater aquifer philosophy' suggests that with sufficient data it is possible to make predictions regarding groundwater with near 100% accuracy (DWA, 2010). It is the opinion of the authors of this report that near 100% accuracy predictions for aquifers is only achievable in theory. In reality experts will never have sufficient data to make such precise predictions and, therefore, groundwater cannot qualify as complicated. For this reason, it seems reasonable that this report defines groundwater as a *complex* system.

Even if sufficient evidence is found to support the 'complicated' theory for aquifers, once aquifers are combined with the plethora of requirements and issues surrounding groundwater governance, groundwater can only be complex. The interaction of groundwater governance institutions, groundwater users,

groundwater resources, associated ecosystems and climate cannot be predicted with any degree of certainty. It therefore seems sensible and necessary to treat groundwater governance as complex (arising from the interaction of many feedback loops, rather than a simple system comprising only one feedback loop).

If groundwater governance is a complex system, then the idea that a specific input can lead to a specific output must be abandoned. Instead, features of complex systems that can be useful need to be found. Even though the end results of interventions can be highly uncertain, it is possible to identify variables that have more influence on the system than others.

The 'command and control' approach denies complexity and is, therefore, not suitable for the diagnostic approach. The diagnostic approach can only be applied when groundwater governance as a complex system is a given.

Simply, the diagnostic approach involves a detailed analysis of a particular case and unpacks the key variables that make and do not make governance work. The variables are then systematically re-packed to design a governance system that works (Young, 2011).

Young et al. (2008) explain this process thus:

"Because institutions interact with a range of other factors, a diagnostic approach to designing specific institutions works better than a search for design principles or generalizations applicable to the full range of environmental and resource regimes. Diagnostic queries seek to probe the nature of the problem, the overarching political setting, the character of the actors or players, and the prevailing practices. The goal is to build up a composite picture of all major factors contributing to a specific issue …"

Young (2011) compares the diagnostic process to building a bridge – a specific analysis would be done in a specific location to decide on exactly what type of bridge is needed. There would not be a general search for 'the world's best bridge' and then simply importing the specifications to a specific site. This is exactly the same with the diagnostic approach that accepts each institutional setting is different and does not try to import the 'best' institution based on a literature review. Whether a bridge is being built, or an institution is being designed, there are still general rules that can be followed that will assist in the specific, local design. When building a bridge there will be rules regarding e.g. the composition of the concrete to be used. With institutional analysis and design using the diagnostic approach there have been sets of 'rules' built up on how to best proceed with the diagnostic approach. At the very least, the 'rules' regarding the diagnostic approach help to ensure that important variables have been included, and that resources are not wasted in an attempt to analyse the mass of unimportant variables.

The three diagnostic approaches presented in this report are:

- Institutional Analysis and Design (IAD).
- Nested, Multitier Framework for analysing Social Ecological Systems (SES).
- Management and Transition Framework (MTF).

There are numerous other approaches that can be used, but these three were selected for the investigation because:

- IAD has been in use and tested for many decades,
- Nested, Multitier Framework for analysing SES specifically looks at ecosystems, and
- MTF has been used to study groundwater.

The Institutional Analysis and Design (IAD) Framework and the Nested, Multitier Framework for analysing Social-ecological Systems (SESs) have been developed to aid in the study and analysis of complex human systems and complex socio-ecological systems respectively. Both Frameworks are the product of years of collaborative, global, interdisciplinary research as well as research carried out at The Workshop in Political and Policy Analysis located at Indiana University, Bloomington. The Workshop has served as a 'hub' for research undertaken around the globe on relevant topics, including the connection between ideas and what gets done. The importance of the work carried out at the Workshop was indirectly acknowledged in 2009 when Elinor Ostrom was awarded the Nobel Prize in Economics. The IAD Framework and the multitier Framework for SES have proved very useful in the analysis of Common Pool Resources (CPR).

The Management and Transition Framework (MTF) was a diagnostic approach developed at the University of Osnabrück. It is to some extent developed from the IAD process, but was designed to be used specifically for analyzing water governance. The MTF was further refined by Knüppe and Pahl-Wostl (2011) specifically for the analysis of groundwater.

The subsequent sections will provide definitions of IAD, multitier framework for SES, and MTF, and provide a simplified explanation of how each Framework is constructed and how it is used. Rather than going into extensive details of how these Frameworks are constructed and used (since this is available in the referenced articles), just enough detail is provided to equip readers with the information needed to make a decision regarding the applicability of the Frameworks to this groundwater governance project.

4.2.4.2 Institutional Analysis and Design (IAD)

Definition, additional background and explanation

The IAD framework is described by Polski and Ostrom (1999) as a tool for conducting, ***'…systematic policy analysis activities.'*** The Framework is the end result of various studies started in the 1950s by the Ostroms and colleagues on the water industry in California, the overutilization of groundwater at a basin level and the study of police departments in U.S. metropolitan areas (Ostrom, 2009).

The motivation for the development of the IAD Framework was the need for a method to analyse complex human systems, in particular institutions. Polski and Ostrom (1999) argue that, 'past oversight of the importance of institutions is due, in part, to the inherent difficulty of analysing them.' Before the development of the IAD Framework, tools for the study and analysis of institutions were inadequate precisely because institutions are so complex. The Frameworks helps avoid developing and applying a 'blueprint' model to institutions and situations that might differ significantly.

While the authors acknowledge the difficulty in defining the term 'institution', they suggest that institutions, '…alone or in a set of related arrangements, [are] mechanisms for adjusting behaviour in a situation that requires co-ordination among two or more individuals or groups of individuals.' Ostrom (2009) suggests that institutions could include; 'human interactions within markets, private firms, families, community organizations, legislatures, and government agencies.'

How IAD works

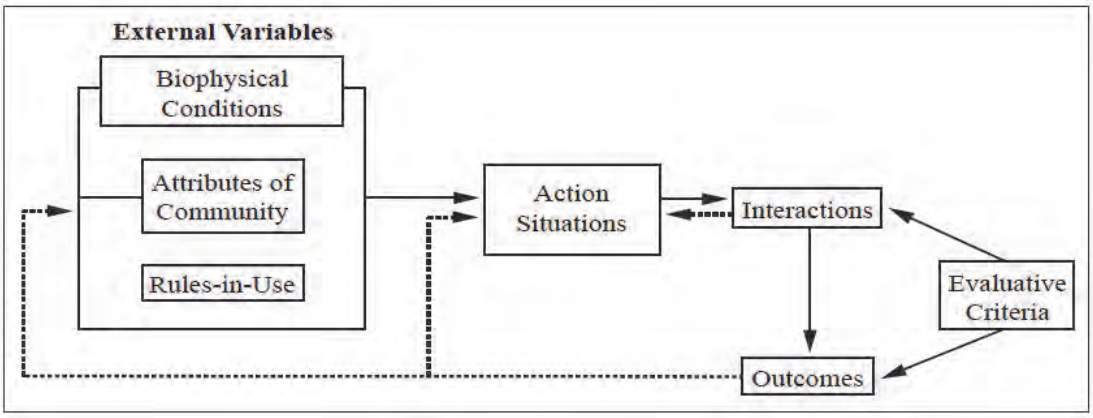


Figure 5. Institutional Analysis and Development Framework (Ostrom, 2009a)

Figure 5 gives a broad illustration of the flow of factors and connections involved in the use of IAD. In their article, An Institutional Framework for Policy Analysis and Design, the authors (Polski and Ostrom, 1999a) provide a detailed step-by step guide to the use of the IAD Framework. The information provided here is taken from the article.

1) **A policy question or problem needs to be identified.** The IAD Framework can be used backwards or forwards. Backwards would entail using it as a 'diagnostic tool' to evaluate whether or not an existing policy (structure, content, outcomes, objectives) is effective in its present form or if it requires revision and reform. Working forwards would be useful in developing 'new policy initiatives'. This would require identifying the inputs e.g. available groundwater, the users/community, the institutions, current rules, the pattern of interaction between all the variables and the outcomes.

2) **Physical and material conditions need to be analysed**. The authors describe these as the 'physical and human resources and capabilities related to providing and producing goods and services.' The economic nature of the goods and services should also be identified using standard economic theory – whether or not access to the goods or service can be controlled (excludability) and how much of the goods and services an individual consumes (subtractability).

3) **Community attributes need to be analyzed**. The community should be analyzed in terms of its demography, particularly the homogeneity or heterogeneity regarding 'values, beliefs and preferences' as they relate to policies and their outcomes. The authors point out that analyzing communities and their culture is difficult and that in their studies, the 'validity and reliability of (their) conclusions are frequently controversial.'

4) **Rules in use should be analyzed.** The authors list seven types of rules to be analyzed: position, boundary, authority, aggregation, scope, information and payoff.

5) **Integration of the analysis**. The most important aspect of IAD is analyzed in this step i.e. the action arena. In this 'conceptual space' the 'actors' (who have different roles to play and are influenced by internal and external factors) gather information, make and act on decisions, modify courses of action and see the results of their courses of action.

6) **Patterns of interaction need to be analysed.** In this step the behaviour of the 'actors' within the action situation is analysed. The authors suggest that it is easier for researchers to make predictions if the policy action situations are 'constrained' (follow a fixed pattern) but are more difficult to predict when the patterns of interaction become more ambiguous (e.g.) new institutions or innovations spring from decisions made in the action arena.

7) **Outcomes need to be analyzed**. The authors describe this step as, 'analysing the performance of a policy system' but in order to analyse performance an 'objective standard' is required for comparison. Evaluative criteria suggested by the authors include: economic efficiency, fiscal equivalence, distributional equity, accountability, conformance to general morality, and adaptability.

4.2.4.3 Nested, Multitier Framework for analyzing SESs

Definition, additional background and explanation

Unlike the IAD Framework, that was designed to analyse any institution (private sector, public sector, informal, and formal) the purpose of the Nested, Multitier Framework for SESs is to specifically analyse socio-ecological systems at an appropriately complex level. In order to avoid oversimplification or the use of blueprints in the analysis of SESs, the framework is nested and multitier. Ostrom (2007) argues that applying inadequate 'policy panaceas' will not lead to the sustainability of SESs. This Framework seeks to provide a 'central' method of analysis for SESs, rather than attempting to bring together isolated and different analytical methods from various disciplines.

How the Nested, Multitier Framework for SESs works

Figure 6 shows the broad factors involved in the Framework (the highest tier). This provides a 'broad conceptual map' that can serve as a point of departure in the study of SESs. The starting point would obviously require a clear research question or problem. At this level the resource system, resource units, governance system and users can be identified and a broad analysis can be made of how these systems interact, are affected by one another and how they relate and are affected by the general socio-economic, socio-political and environmental conditions. Ostrom describes SESs as 'decomposable systems'; hierarchical levels where lower levels are 'sub-divisions' of the levels above.

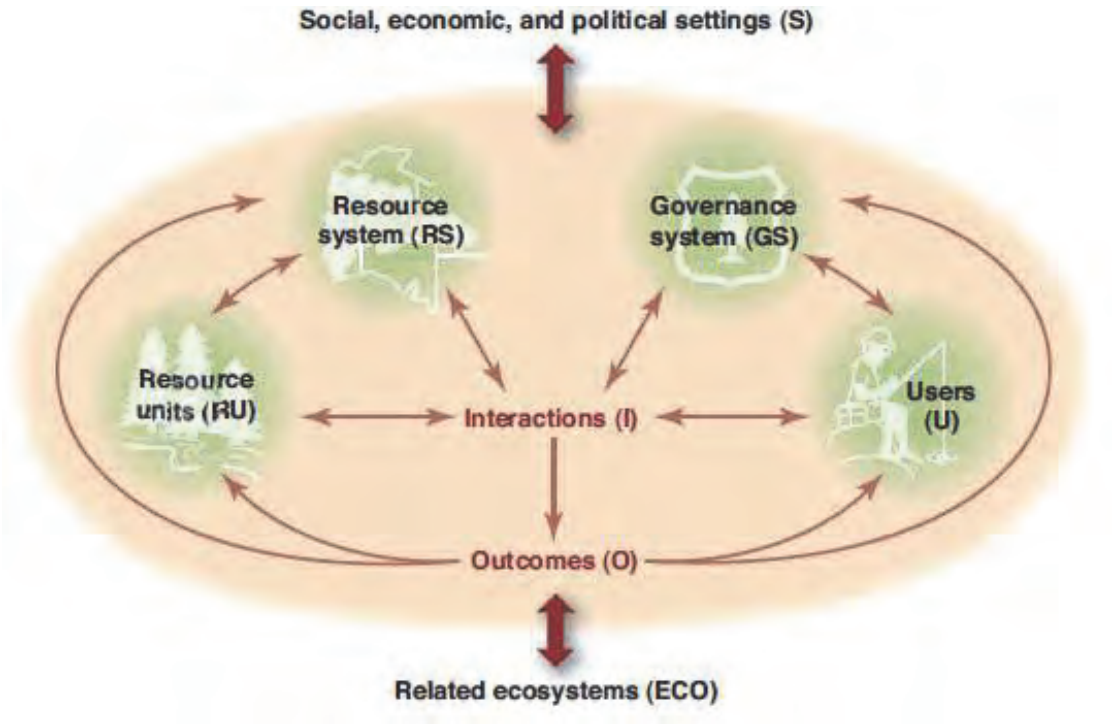


Figure 6. Nested, Multitier Framework for SES (Ostrom, 2009b)

Table 4 provides a list of the possible variables (identified by different researchers and collated into a single list) that need to be identified at a second tier level. Only those variables relevant to a particular study should be investigated. Ostrom proposes that how complex and multitier a Framework becomes is dependent on the goals of the researcher/s and the policy question at hand. In other words, should the investigation go to e.g. a third, fourth, fifth, etc. tier level? And once these variables have been selected, how many and how much should each of these second tier variables be 'unpacked'.

Table 4. 2nd Tier SES variables (Ostrom, 2009b)

Social, economic, and political settings (S)	
S1 Economic development. S2 Demographic trends. S3 Political stability. S4 Government resource policies. S5 Market incentives. S6 Media organization.	
Resource systems (RS)	*Governance systems (GS)*
RS1 Sector (e.g., water, forests, pasture, fish)	GS1 Government organizations
RS2 Clarity of system boundaries	GS2 Nongovernment organizations
RS3 Size of resource system*	GS3 Network structure
RS4 Human-constructed facilities	GS4 Property-rights systems
RS5 Productivity of system*	GS5 Operational rules
RS6 Equilibrium properties	GS6 Collective-choice rules*
RS7 Predictability of system dynamics*	GS7 Constitutional rules
RS8 Storage characteristics	GS8 Monitoring and sanctioning processes
RS9 Location	
Resource units (RU)	*Users (U)*
RU1 Resource unit mobility*	U1 Number of users*
RU2 Growth or replacement rate	U2 Socioeconomic attributes of users
RU3 Interaction among resource units	U3 History of use
RU4 Economic value	U4 Location
RU5 Number of units	U5 Leadership/entrepreneurship*
RU6 Distinctive markings	U6 Norms/social capital*
RU7 Spatial and temporal distribution	U7 Knowledge of SES/mental models*
	U8 Importance of resource*
	U9 Technology used
Interactions (I) → outcomes (O)	
I1 Harvesting levels of diverse users	O1 Social performance measures (e.g., efficiency, equity, accountability, sustainability)
I2 Information sharing among users	
I3 Deliberation processes	
I4 Conflicts among users	O2 Ecological performance measures (e.g., overharvested, resilience, bio-diversity, sustainability)
I5 Investment activities	
I6 Lobbying activities	
I7 Self-organizing activities	O3 Externalities to other SESs
I8 Networking activities	
Related ecosystems (ECO)	
ECO1 Climate patterns. ECO2 Pollution patterns. ECO3 Flows into and out of focal SES.	

*Subset of variables found to be associated with self-organization.

Ostrom argues that the framework is designed to prevent 'method wars'. The framework is simply the 'backbone' into which research conducted at 'multiple conceptual levels' and using diverse methods can be knitted together.

4.2.4.4 Management and Transition Framework (MTF)

The motivation for MTF (Pahl-Wostl et al., 2010) was, in general, to provide a systematic approach to looking at complexity, and specifically, to provide a certain of formalization and standardisation in data collection and analysis protocols so that an improved understanding of water governance could be obtained by both looking at individual case studies in rich detail, as well as for allowing a correlation analysis across a large number of case studies. The conceptual basis of MTF is primarily:

- IAD.
- Adaptive management and the characteristics of adaptive management water regimes.

- Social learning.

The MTF process involves collecting data from legal reports, peer-reviewed journals, and interviews. This mass of data is entered in a relational database for further analysis. The analysis is guided by a set of working hypotheses. In this case of the adaptive capacity of multi-level governance three hypotheses are proposed (Pahl-Wostl et al., 2010):

- High centralization of governance regimes reduces adaptive capacity and is a barrier to social learning.
- A lack of vertical integration reduces adaptive capacity and is a barrier to social learning.
- Adaptive capacity is highest in regimes characterized by a balance between top-down and bottom-up flows of authority/influence.

Knüppe (2012) adapted the MTF for a comparative study of groundwater governance in the Sandveld (South Africa), Upper Guadiana Basin (Spain), and the Spree Basin (Germany).

Knüppe and Pahl-Wostl (2011) outline the management and transition framework (MTF) in order to look more specifically at the management and governance of groundwater. As in the case of the IAD and the multitier SES framework, the MTF is designed to help unravel the complexity of governance and management of environmental systems. Since governance of groundwater is still a poorly understood area, there is a need to study and analyse different groundwater case studies. When examples of good groundwater governance are found, this experience and knowledge could be transferred to other groundwater where conditions are similar and problems exist.

Knüppe and Pahl-Wostl (2011) suggest that in order to improve governance, 'vertical integration' is needed (improved connection between all levels of administration), management should be adaptive (able to change when needed), and connections between all actors need to be strengthened (all users, regulators, managers, and institutions).

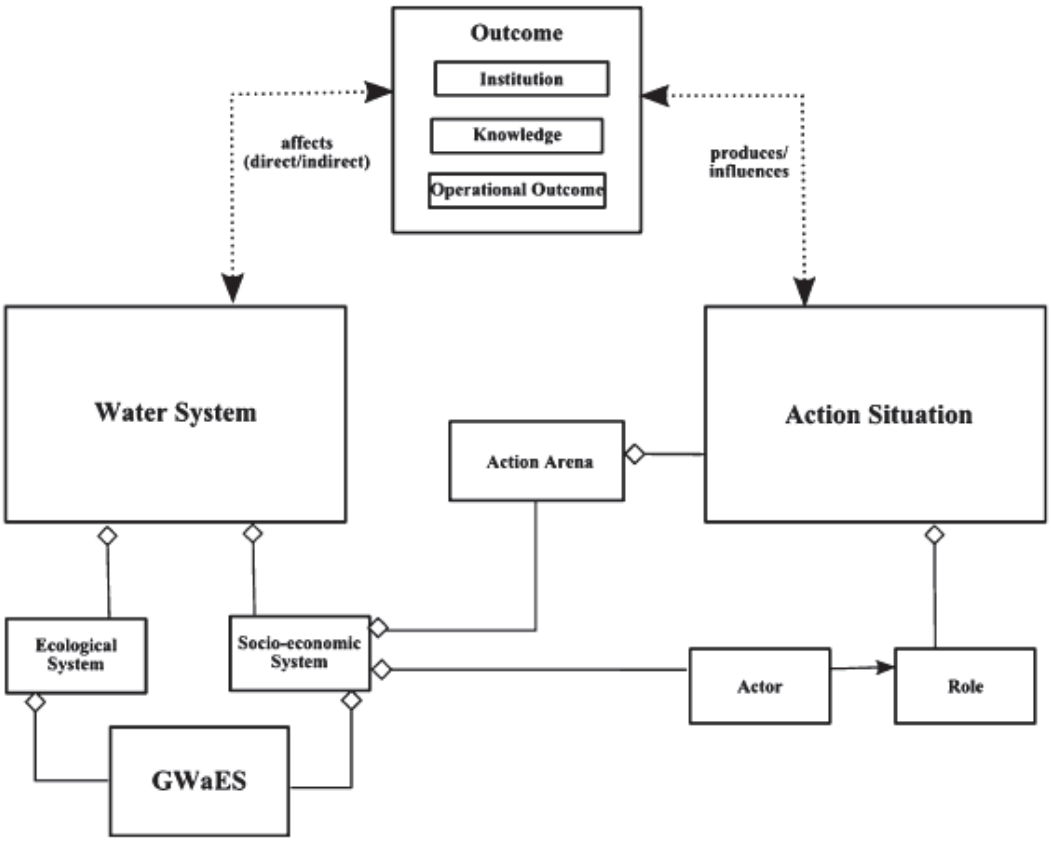


Figure 7. Management and Transition Framework (MTF) Class Diagram (Knüppe, 2012)

[GWaES = Groundwater Associated Ecosystem Services]

The MTF class diagram (Fig. 7) represents what the author's refer to as a 'static representation'. It illustrates the crucial elements within the water system and their relationship and linkages to one another:

- **The water system** (which includes 'location, hydrological characteristics, population density and climatic conditions') is the central class.
- **The ecological system** includes 'abiotic and biotic components of the groundwater body and related ecosystems such as floodplains, swamps, springs and sloughs'. The authors note that in the case of large aquifers, there might be more than one ecological system.
- **The socio-economic system** relates to the political, religious, spiritual, historical context of the people within that water system.
- **The GWaES** may be a 'public, private or collective good'. Other important factors affecting the GWaES are the economic value placed on it and variability of the resource (if it is affected by drought etc.).

The GWaES is then connected to:

- **The action situation** ('a structured social interaction that leads to a specific outcome that influences the elements of the water system and vice versa').

- **The action arena** (different policy sector and contexts related to the management of GWaES).
- **Actors** of 'members' of the socio-economic sector (individuals, government and non-governmental institutions etc.) and have goals such as protection of the environment, or increased agricultural production.
- **The role** refers to the actor's role in the action situation.

The outcomes of the framework include three variables:

- **Knowledge** (understanding, experience, and information regarding the water resource)
- **Operational outcome** (is the 'measurable effect' of management on groundwater)
- **Institutions** *(*the regulations and laws designed and used to manage groundwater*)*

In addition to the 'static representation' (above) the authors include a second dimension to the framework. They call this the policy cycle. They describe this dimension as 'dynamic' (Table 5). A phase of the policy cycle is applied to each 'action situation'. The example given by the authors is the 'implementation of groundwater protection zones' as part of the 'implementation' phase of policy.

Table 5. Phases of the [MTF] policy cycle (Pahl-Wostl et al., 2010)

Phases of the policy cycle	
1. Strategic goal setting	The strategic goals for the management process are set to determine a desirable state of the entire water system, including both socio-economic and environmental goals and values (social, economic or ecological). The strategic goals are formally binding for all actors.
2. Assess the current state	The current state of the water system is assessed to estimate the distance of the current state from the desired goal state. Hence it is possible to determine satisfaction and the need for change.
Note: After a first comparison of the current system state; the strategic goals allow determining the degree of deviation from the desired state and estimating the need for action. At this stage it is already possible to adjust strategic and more promising or important goals according to the current state.	
3. Policy formulation	Policies are developed that represent coherent approaches how and in which time frame improvement of the current state of the water system is initiated. This phase may include an interpretation and refinement of the strategic goals and it can be expected to involve different stakeholders, who pursuing their goals and try to influence the policy process.
4. Developing operational goals	Operational goals are defined that allow assessing efficiency and effectiveness of measures and that are the basis for monitoring.
5. Developing measures	A plan with specific measures including an assessment of their costs and expected effectiveness is developed.
Note: Take into account' Best Practice Examples' from other cases to learn from failure or success stories. Before implementing measures inform and educate the local community to achieve a successful implementation process; e.g. organize workshops and public events, communicate via internet or newspaper, etc.	
6. Implementation	In this phase the measures are implemented on the ground at the appropriate level e.g. improvement of infrastructure to save water, introduction of new water pricing policies.
7. Monitoring	Monitoring means reviewing the implemented measures as to achievement of the strategic goals. Therefore it is possible to detect potential unexpected and undesired consequences.
Note: At this state the process may go back to the first phase (or any other phase) and strategic goals may come under scrutiny.	

Knüppe and Pahl-Wostl (2011) applied the framework to a case study of the Upper Guadiana Basin. They used the framework to ascertain that management at the time of the study was an obstacle to sound, adaptive management. They established that communication between 'administrative levels' was poor and that the bureaucratic system was 'rigid. This led to the identification of required changes in management style, including better vertical integration from the bottom up. The authors note that utilizing the framework effectively requires good quality and accessible information.

4.2.5 BACKCASTING

Backcasting essentially involves defining a vision of a desired future, and carrying out an analysis of the actions required to realize this vision (Van Vliet & Kok, 2015; Wangel, 2011). Backcasting thus involves:

a) Defining a future desired setup/process/scenario.

b) Working backwards to identify what steps (policies, programmes, actions, etc.) are needed to connect the desired future to the present. 'Joining up the dots' to move from the status quo to the desired scenario.

> Backcasting is not so strange an exercise as might first appear. Think of planning a holiday. You do not leave home and drive aimlessly. Rather, you first choose a destination and figure out how to get there. Backcasting is an iterative process. You do it over and over until reasonably satisfied that the goal can be achieved in the most cost-effective and agreeable way possible.

Text Box 2. Backcasting (Brandes and Brookes, 2007)

The setting of Resource Quality Objectives under South Africa's NWA (RSA, 1998) is an example of the backcasting process. For example maximum groundwater drawdowns might be determined so as protect an important ecosystem, and then abstraction rates, drawdowns and radial distances 'backcasted' so as to ensure the maximum drawdown is not exceeded.

Backcasting was used by the Texas Water Development Board (Gleeson et al., 2012) to reach sustainability goals, referred to as 'desired future conditions,' for groundwater levels, storage and spring flows. Maximum pumping rates for the desired sustainability goals were then determined using groundwater flows. This is a highly technical form of backcasting, but does illustrate its key components: identifying a desired future, and identifying what needs to be done to realise that future. Thus backcasting, unlike forecasting, does not attempt to predict what is likely to happen. Instead it describes a desired future end-point, and then works backwards to determine the feasibility of that end-point and the policies required to reach that point (Robinson, 1990).

Backcasting is more commonly used for broad societal aims (Robinson, 1990), and for the specific business and strategic plans of corporations (Dreborg, 1996). Backcasting can be regarded as a very specific type of scenario studies, since both are concerned with descriptions of what might happen rather than trying to forecast the future. Whereas scenario studies in general might typically look at a range of future conditions – desirable and undesirable, in order to facilitate preparedness and planning for any of those conditions, backcasting looks specifically at desired future conditions in order to identify what could be done to realise those conditions (Dreborg, 1996).

A limitation in the application of backcasting is that it does not always pay sufficient attention to the role of institutions responsible for implementing the backcasting plans. For example, Gleick et al.'s (1995) proposed backcasting solutions for California's water issues, while full of plans and programmes for water management, pays scant attention to the institutional changes needed to implement these plans and programmes. Not paying sufficient attention to the institutional constraints affecting the implementation of a backcasted scenario seems a common failing (Nilsson et al., 2011) in many environmental issues. For these reasons backcasting needs to be applied to institutions and not just to the plans and programmes for groundwater, environmental and/or socio-economic scenarios.

In addition it can be difficult to envisage what the desired sustainability landscape will be in the future. In these situations, backcasting processes for dealing with

future negotiations over sustainability issues seems a much more credible, pragmatic, and useful exercise than trying to envision actual sustainability issues.

4.3 Rationale For Methodology Selected

The literature review has shown that there is no existing good groundwater system that can simply be imported into the South African situation. The literature review also revealed that groundwater governance research is still in its infancy as is research on appropriate methodologies to do groundwater governance research. Because of the embryonic state knowledge of good groundwater governance and groundwater governance research methodologies, this chapter looked in considerable depth at methodologies that might be considered for this project. Each methodology has pros and cons:

Case Studies: Given that groundwater governance analysis is in its infancy, and given so few examples of good groundwater governance have been identified, there is clearly value in doing exploratory, open-ended research. In contrast, simply adding one or two more case studies' empirical data to the small body of existing data on groundwater governance has little practical value. The small body of existing data means there is also little practical value in attempting to extract empirical rules about good groundwater governance by looking at groundwater case studies and doing statistical analyses. It is very difficult to see how this approach could currently be helpful in extracting general rules, and then using these general rules to identify key interventions.

World Bank's 20 Benchmarking Criteria: This checklist has the advantage of being groundwater specific, and provides a 'common langue' so that different areas can be meaningfully compared. While the checklist is based on the practical experience of experts, there is – as yet – little documented, peer-reviewed academic, research to prove whether all the factors on the checklist do in fact engender good groundwater governance or not. A more pragmatic concern is that the checklist – when applied to the South African situation – showed that most of the criteria were absent, thus giving little practical guidance on which of the criteria were the most critical and should be identified as key interventions.

Ostrom Design Principles: A cursory test of the ODP in the South African context showed that they suffered the same problem as the World Bank's checklist – most of the design principles are not present in the South African groundwater governance situation. Thus, they are of limited value in narrowing down possible interventions to one or two key interventions. However – unlike the World Bank's benchmarking criteria – the ODP have been 'battle-tested' and have been shown to correlate well with good common pool governance in a wide variety of contexts. Since groundwater is also a CPR – or rather only needs to be managed when it is a CPR – there are sound arguments for using it in the groundwater field.

Ostrom started her career in CPR governance studies with a PhD on groundwater governance in California (Ostrom, 1965). It is from work such as this that the ODP emanated, so there are strong historical connections between groundwater governance and the design principles. For this reason, the ODP seem an appropriate approach to the analysis of groundwater governance.

Diagnostic Approaches Incorporating Various Frameworks. From a conceptual and academic point of view, approaches such as 'Institutional Analysis and Design,' (IAD) and the 'Management and Transition Framework' (MTF) seem to be the most rigorous approaches. With these approaches, it is possible to establish why a particular governance system is not working and what is needed to 'fix' that system. However the rigour of these approaches does not come without complexity. While there are eight ODP (eleven if the A, B splits are tallied) and 20 World Bank benchmarking criteria, the IAD and MTF approach have an almost infinite number of criteria that might be considered. This is not very helpful when trying to isolate one or two key interventions. And when conclusions are drawn in the process of using these approaches, they are too general e.g. 'improve vertical integration of governance activities.' This kind of conclusion is helpful, particularly from an academic point of view, but does not provide the practical guidance this report is searching for.

The authors of this report found the frameworks for the implementation of diagnostic approaches difficult to understand or follow. The authors surmise that they are possibly more suitable to be utilized by the teams that designed them. For example, the IAD was developed by the Indiana University and appears to only have been used by that institution. The same applies to the MTF, which was designed by the University of Osnabrück and appears to only have been used by that institution. Rather than becoming clearer to understand as the unpacking process progresses, the frameworks became increasingly difficult to follow.

Backcasting involves defining a future and then working backwards to identify what step are needed to connect the present to the desired future. The emphasis on identifying steps seems well suited to identifying interventions as required by this project. However, given the paucity of knowledge available regarding good local groundwater governance, it is uncertain whether it will be possible to identify the desired steps and/or fail to include something which needs to be included.

For the reasons laid out above, it was decided that a combination of backcasting and the ODP would be the optimum research methodology for this investigation. The justification for singling them out as the most suitable 'methods' are that, (a) backcasting will help identify and prioritise the interventions needed; (b) the ODP will help ensure that a wide enough range of issues is addressed; and (c) the ODP have been tested empirically.

An additional reason backcasting was selected is because it focuses attention on a desired future and provides insight on how to get there. It does not focus attention on current problems and the socio-technical constraints preventing change (Dreborg, 1996; Wangel, 2011). In the South African context, it is difficult to get water experts and government water managers to consider alternatives to the status quo or to think beyond a current crisis (Claassen, Funke, & Nienaber, 2011). There is

a risk that focusing on short-term solutions to short-term problems will lead experts and managers further away from a desired future than closer to it. Backcasting steers managers and experts toward an identified end goal, rather than allowing the problem-solving process to focus excessively on the 'here-and-now'.

Since this report uses methodologies that are, in themselves, under-researched, this report proposes that the methodologies will be subject to scrutiny and analysis and not assumed to be correct.

4.4 Details Of Methodology Selected

4.4.1 INTRODUCTION

The ODP in conjunction with backcasting were selected as the most appropriate methodologies. These methods allowed for 'deeper' investigation into groundwater governance thereby facilitating the identification of the key interventions required to improve local groundwater governance.

4.4.2 IDENTIFYING THE INTERVENTIONS

The approach to backcasting used in this investigation was to backcast desired institutional *processes* for realising desired groundwater scenarios rather than attempt to backcast desired groundwater *scenarios*. The specific processes addressed were those needed to improve groundwater governance. The starting point for the backcasting exercise was a definition of good groundwater governance since progression towards good groundwater governance is impossible unless it is known what good groundwater governance means.

Starting with a generalized definition of good groundwater governance, the project works backwards in increasing detail and decreasing abstraction, looking at the various component processes in the overall groundwater governance process until the local processes are reached. A preliminary 'conceptual model' (Fig.8) has been constructed to aid this analysis.

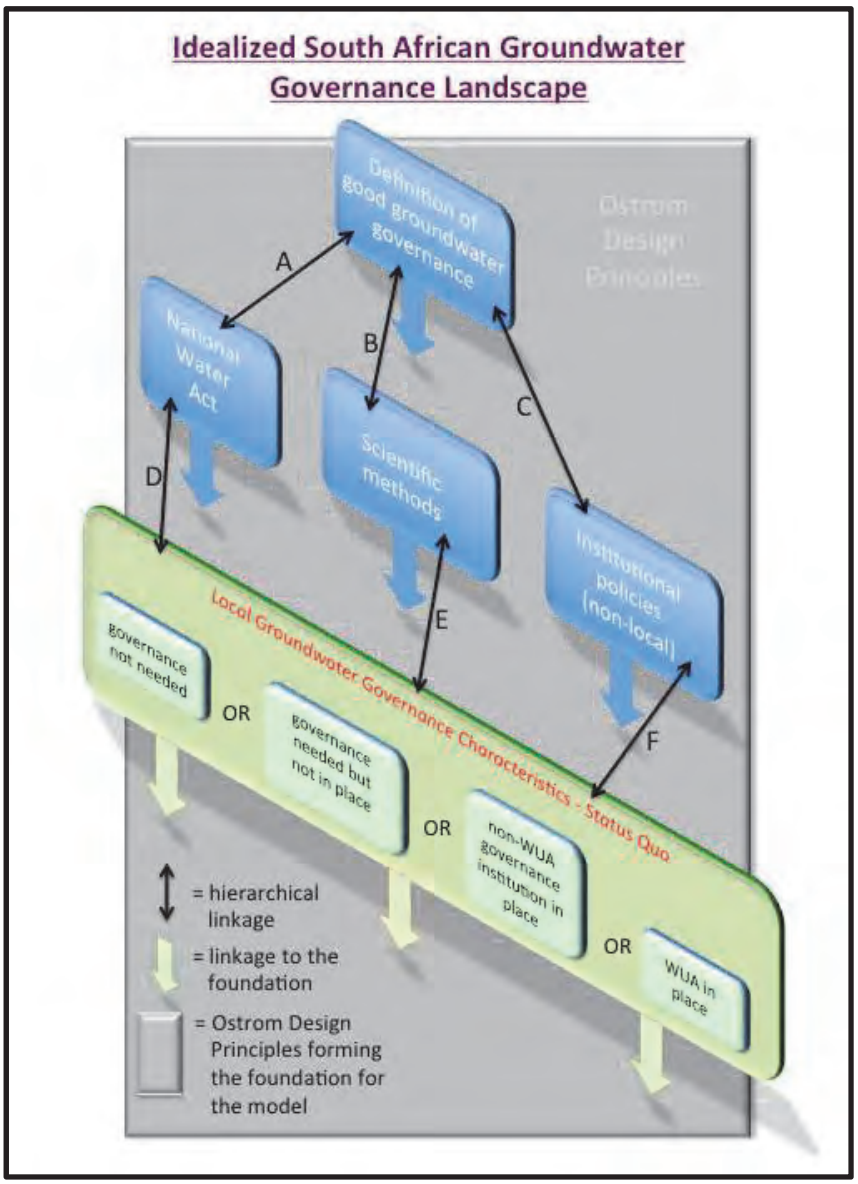


Figure 8. Idealized South African Groundwater Governance 'Landscape'

The four different characteristics for the status quo for local groundwater governance are depicted as a reminder that local groundwater governance will be at different levels of development in different areas. In some areas groundwater governance might not be required at all.

Since backcasting is about starting with an ideal and then working backwards to identify what is needed to realise the ideal, this project will start with the ideal of 'good groundwater governance'. It will be assumed that this ideal has been met if the ODP have been adopted at all levels of governance – from the definition of groundwater governance right down to individual actions at the local level. The following question is then posed: what needs to be done to move from the current status quo to the ideal?

Backcasting will be looked at from two, intersecting, planes or 'dimensions.' In the first dimension backcasting starts from a very general definition of good groundwater governance and then works backwards to what this means in terms of

specific actions at the local governance level. In this 'dimension' it is the linkages between the hierarchies that are being investigated to reveal any interventions that are needed. In the second 'dimension' backcasting starts with what is understood to be good governance at the definition, support, and local levels as informed by the ODP. It then works backwards to what is currently happening, thereby identifying any interventions that might be needed. In the second 'dimension' it is the linkage between *ideal* and *actual* that is being investigated to reveal any interventions that might be needed. Since, in practice, these two 'dimensions' are closely – possibly inextricably – interwoven, they will be analyzed together.

For each linkage between different hierarchical levels of detail/abstraction the 'conditions of possibility' (Kant, 1781) will be established. In other words the question will be asked:

- What conditions are necessary for the higher level to be linked to the lower level?

Once this question has been answered, two further questions will be asked:

- Are these conditions already in place?
- If not, what INTERVENTIONS are needed to make these conditions possible?

The hierarchical linkages (Fig.8) to be addressed are:

A: definition of good groundwater governance <—> NWA

B: definition of good groundwater governance <—> Hydrogeological Science

C: definition of good groundwater governance <—> non-local institutions (National, Regional, CMA)

D: NWA <—> local groundwater governance

E: Hydrogeological science <—> local groundwater governance

F: non-local institutions <—> local groundwater governance

It was found that trying to analyze steps D, E and F separately for each case study area was unnecessarily repetitive and complex and therefore factors D, E and F were treated together for each case study area.

Since so little is known about good groundwater governance, this investigation is exploratory in nature. Because of this exploratory approach a rigid methodology was not applied, but left to evolve as the investigation proceeded. Thus any insights learnt regarding useful methodologies will be included in the results.

4.4.3 CASE STUDIES

This project is using an idealised, 'conceptual case study' for part of its analysis. In the imaginary/conceptual case study area good groundwater governance already exists. The project then backcasts from the conceptual case study area to the physical case study areas. The physical case studies areas selected were:

- **Governance needed but not in place:** Phillipi Horticultural Area – data collected and analyzed by University of the Western Cape Honours student Zodidi Mgxekwa as part of this project.

- **Non-WUA governance institution in place:** Hermanus Monitoring Committees – data collected and analyzed by University of the Western Cape Honours student Mandilakhe Msutu as part of this project.
- **WUA in place:** Northern Sandveld WUA – data obtained from (1) PhD thesis by Kathrin Knüppe (2012), University of Osnabrück, Germany, and (2) principal author's DWA experience.

The case studies were subject to a more intense scrutiny than the supporting framework provided by science, law, and institutions, since it is at the local, implementation level where the major problems exist, and because it is the local level that is the focus of this investigation.

4.4.4 DETERMINING THE KEY INTERVENTIONS

When all the linkages have been analysed, the interventions will be grouped together and/or ranked so as to determine the 'key interventions'. The term 'key interventions' was chosen deliberately because it acknowledges the possibility that there may be 'leverage points' (Meadows, 1999) where a relatively modest intervention will lead to relatively large improvements that are out of proportion to the size of the initial 'investment.' The key interventions will be determined by the ratio of the cost/size of the intervention input to the benefit/size of the likely improvement in groundwater governance.

Depending on the results obtained, the interventions will be ranked using the principal author's extensive DWA experience so as to determine the key, i.e. priority interventions, or they will be grouped into overall 'umbrella' interventions so as to determine the key interventions.

5 IDENTIFYING POSSIBLE INTERVENTIONS

5.1 The Starting Point: Good Groundwater Governance

The purpose of this project is to identify key interventions to improve groundwater governance at the local level. Deliberate attempts to improve groundwater governance obviously require an understanding of what good groundwater governance means. Much debate has gone into the definition of groundwater governance and good groundwater governance (Wijnen et al., 2012). For the purposes of this investigation the following definitions will be adopted Moench et al. (2012):

GROUNDWATER GOVERNANCE:

"The process through which groundwater related decisions are taken (whether on the basis of formal management decisions, action within markets, or through informal social relations) and power over groundwater is exercised."

GOOD GROUNDWATER GOVERNANCE:

"A 'good' groundwater governance environment is one where governance processes equitably reflect the voices and interests of stakeholders (including regional and global stakeholders with interests in resource sustainability) and where broadly supported courses of action can be implemented in an effective and equitable manner."

These definitions state and/or imply the following characteristics:

- Groundwater governance is a process.
- A process whereby decisions related to groundwater are made.
- Decision-making accommodates individual users to global institutions.
- 'Good' groundwater governance involves:
  - fair, equitable decision-making.
  - effective implementation of decisions.
  - effective enforcement of decisions.
- Undesired and/or unplanned outcomes do not equal bad governance.
- If the governance process is resilient enough to respond to 'unsatisfactory' outcomes it is still 'good governance'.

Extensive research and consideration has been given to the selection of the most suitable definition/combination of definitions of good groundwater governance. It could be argued that the definition selected for this project is simply the project team's arbitrary personal preference, and that there are other equally valid, alternative, definitions that could have been utilized. The findings of this report suggest that the selected definitions represent the best synthesis of what has emerged from the literature review and the meaning of governance as it pertains to groundwater. The subject remains open to debate and there is therefore a need for wider input and stakeholder consensus on what good groundwater means. This lack of clarity and consensus regarding *what* good groundwater governance *is*, requires an intervention.

INTERVENTION 1: Obtain consensus on a definition of good groundwater governance.

5.2 Linking Good Groundwater Governance To The Ostrom Design Principles

The preceding section has provided a definition of good groundwater governance. The ODP are concerned with the sustainable governance of CPRs. Ostrom's heuristic (1990, 2005) is that the more of the ODP that are present, the more likely that the local-scale common pool governance will be sustainable. Cox et al. (2010) in a meta-analysis of 91 case studies that had utilized the ODP found the principles to be robust. Thus, for good groundwater governance to pass the 'conditions of possibility' test for linkage to the ODP, the 'good' in good groundwater governance must allow for 'sustainable' as in the sustainable governance of CPRs, and groundwater must be capable of being considered a CPR.

It seems obvious that 'good' governance and 'sustainable' governance are not mutually exclusive, and thus 'sustainable' permits 'good' governance, and vice versa.

Thus for good groundwater governance to be capable of being linked to the ODP simply requires that groundwater is – or can be treated as – a CPR. A CPR is one for which the right to use is shared with others in a way that one person's use subtracts from another's use, and where it is difficult to exclude members of the community from using the resource (Table 6). The issue of excludability is somewhat arbitrary and murky because a CPR may seem like a private good to an outsider. For example a communal aquifer cannot be directly accessed unless one acquires property that overlies that aquifer. However, to an insider who has direct access to an underlying aquifer the resource then becomes a common good for that person and the other persons with direct access to the aquifer.

Since aquifers can straddle farm and other boundaries it is clear that one person's use can subtract from another's use. It is also clear that it is very difficult to restrain any given individual who has access to an aquifer. Therefore, groundwater is best considered a CPR, rather than private, public or club goods (Sophocleous, 2010; Llamas and Martínez-Santos, 2005; Giordanio et al., 2012).

Table 6: Four basic types of goods (Ostrom, 2005)

	Excludable	Non-excludable
Rivalrous	**Private Goods** e.g. food, clothing, cars	**Common Pool** e.g. fish stocks, communal pasture, groundwater
Non-Rivalrous	**Club or Toll goods** e.g. toll roads, private parks, satellite television	**Public Goods** e.g. free-to-air television, radio, air, 'Peace'

Dumont (2013) raises concerns regarding the classification of groundwater as a CPR. Dumont argues that treating groundwater as a CPR would (or could) lead to a lack of

consideration for the impact of groundwater use on ecosystems and surface water users. This could be the case if groundwater use only considered consumptive use – i.e. use for direct human benefit, and only sought to arbitrate this use. However, the South African National Water Act (RSA, 1998) includes and/or allows for a wide variety of uses, so there appears no reason why all the competing uses cannot be considered. Representatives of all organisations (those responsible for all competing uses of a communal resource) could give effect to this aspect of the NWA if they were given the right to be involved in the governance of that resource.

Another concern is the scale of resources. The ODP are intended for local scale resources. Certain groundwater systems are far larger than local systems and form regional systems. However, given the extremely slow rate of groundwater movement, it is only practical to manage these aquifers on a day-to-day basis at the local scale. Thus, this concern does not prevent ODP from being used, and being linked to 'good groundwater governance.'

This report contends that groundwater in South Africa is 'sufficiently' common pool and 'sufficiently' local for the ODP to be applicable, and that no further interventions are required to address this matter.

5.3 Linking Good Groundwater Governance To The National Water Act

5.3.1 INTRODUCTION

The National Water Act (NWA) is silent on the topic of good governance. References in the NWA to governance pertain mostly to international treaties. This investigation will assume that if the ODP are in place, good governance will take place.

For the design principles to be capable of being linked to the NWA requires two broad 'conditions of possibility' to be met:

1) The NWA must be capable of giving effect to the design principles.

2) The design principles must be capable of giving effect to the aims of the NWA.

The first 'condition of possibility' was subsequently subdivided into two 'aspects'.

(1) Would the NWA be capable of implementing the design principles in the current institutional or scientific environment, and (2) would the NWA be capable of being implemented by revised institutional strategies but without any changes to the NWA itself? If implementation *was* possible without any changes then no interventions would be required. If implementation *was not* possible even after changes in institutional or scientific polices then interventions to change the NWA would be required. The intermediate intervention required would be changes in institutional polices.

5.3.2 CAN THE NWA GIVE EFFECT TO THE DESIGN PRINCIPLES

Two questions were asked: (1) which design principles are currently implementable given the institutional environment, and (2) which design principles are potentially implementable using existing resources and legislation, but with some changes to

strategies and deployment of resources (Table 7). The reasons for the answers are then discussed.

Table 7. Implementability of the design principles

Ostrom design principle	Currently implementable	Potentially implementable
1A. User Boundaries:	✔	✔
1B. Resource Boundaries:	✔	✔
2A. Congruence with Local Conditions:	✖	✔
2B. Appropriation and Provision:	✖	✔
3. Collective-Choice Arrangements:	✔	✔
4A. Monitoring Users:	✖	✔
4B. Monitoring the Resource:	✖	✔
5. Graduated Sanctions:	✖	✔
6. Conflict-Resolution Mechanisms:	✖	✔
7. Minimal Recognition of Rights:	✖	✔
8. Nested Enterprises:	✔	✔

1A User Boundaries – *'Clear and locally understood boundaries between legitimate users and nonusers are present.'*

Most WUAs are old surface water irrigation boards that have been transformed to WUAs and have little relation to boundaries of groundwater users groups. However, there appears to be no legal reason why new groundwater WUAs could not be established with clear user boundaries. However, this would take some time because new WUAs need Ministerial approval and obtaining such approval can often takes many years.

1B Resource Boundaries – *'Clear boundaries that separate a specific common-pool resource from a larger social-ecological system are present.'*

Existing WUAs do not correspond to groundwater resource boundaries, since they are not primarily concerned with groundwater. However, hydrogeological maps do exist, and most productive aquifer systems are well researched. Therefore, there is no scientific reason why groundwater governance could not be based on clear resource boundaries.

2A Congruence With Local Conditions – *'Appropriation and provision rules are congruent with local social and environmental conditions.'*

Groundwater allocation rules are currently based on a percentage of average annual recharge. This rule has been shown to be overly simplistic and unrealistic for local conditions of groundwater (Bredehoeft 2002; Custodio 2002; Alley and Leake 2004; Seward et al., 2006; Balleau 2013). However, some of the South African scientific community appear unwilling to accept the shortcoming of the 'average annual recharge' rule, and unwilling or unable to develop a better approach. Vivier (2013) for example provides a defence of 'average annual recharge'.

INTERVENTION 2: A paradigm shift in the scientific rules used for groundwater allocations is needed. Current rules based on average annual recharge cannot be substantiated by sound science.

There is no passage in the NWA that says groundwater allocations must be based on annual average annual recharge, nor is there a passage in the NWA preventing 'congruence with local conditions.'

2B Appropriation And Provision – *'Appropriation rules are congruent with provision rules; the distribution of costs is proportional to the distribution of benefits.'*

In other words, in the case of groundwater this could mean that the benefits of belonging to a WUA must exceed the costs and disadvantages, and that there is fair distribution of benefits.

Studies have shown, e.g. Wester et al. (2011), that globally, appropriators appear to see little benefit in belonging to a WUA and fear that membership will restrict their water allocations and income. Short-term economic well-being is of far more importance to them than the sustainability of a groundwater resource. This may or may not apply to the South African situation, but either way the NWA does not prevent the implementation of this design principle.

3 Collective-Choice Arrangements – *'Most individuals affected by a resource regime are authorized to participate in making and modifying its rules.'*

The NWA allows this (to a certain degree) since each member of a WUA has voting rights as prescribed in the NWA that would allow them to participate in changing or modifying their WUA rules.

WUAs in South Africa do have the right to create and modify their rules, but these rules, unless delegated to them by a CMA or the Minister of Water Affairs, would not include water management. Thus, WUAs in South Africa (normally) have no right to curtail or otherwise manage water use, but exist to optimize the entitlements allocated to them by higher institutions. In other words, they may do some watchdog activity for the higher-level institution or provide inputs to that institution, but they would not normally have any more power than that. The National Water Act [NWA] explains the role of WUAs as follows: ***"Although water user associations are water management institutions their primary purpose, unlike catchment management agencies, is not water management."***

However, in order to meet the requirements of Ostrom principle 3, WUAs would have to have water management rights. In theory, this authority could be delegated to WUAs. However, given the paternalistic nature of DWA, an institution that is reluctant to even devolve quite minor functional duties and responsibilities from a national head office to regional branch offices, delegating this authority in practice appears to be a major constraint. Possible workarounds for this constraint could be: (1) the allocation of a water use license to a WUA, who then become responsible for subdividing this allocation to their members, or (2) DWA accepting that the WUA has the moral right to make its own decisions, and then rubber-stamping these decisions when the WUA has no legal authority to do so.

Thus, the NWA does not prevent Ostrom design principle 3 being implemented. However current institutional culture and policies may well prevent a linkage between the NWA and design principle 3. Therefore, an intervention is needed:

INTERVENTION 3: Create institutional policies that allow for, encourage and empower WUAs to make their own water management rules.

4A Monitoring Users – '*Individuals who are accountable to or are the users monitor the appropriation and provision levels of the users.'*

The South African system for water permitting is based on volumetric allocations. To monitor this would require water volume meters to be installed, monitored by the users or individuals accountable to the users, and the data made freely available to the rest of the WUA. This is currently not taking place and thus it could be argued that the NWA is not giving effect to this design principle. However, there is nothing in the NWA that prevents design principle 4A being implemented – using water volume meters or any other means deemed appropriate by the WUA. Unfortunately, the argument made for design principle 3 is applicable once again – institutional culture is unlikely to foster such an approach. Thus, an intervention is needed:

INTERVENTION 4: Create institutional policies that allow for, encourage and empower WUAs to monitor their groundwater use.

4B Monitoring The Resource – *'Individuals who are accountable to or are the users monitor the condition of the resource.'*

Currently, piezometric monitoring by appropriators is almost unheard of in South Africa. Although many significant aquifers may be monitored hydrologically by regional offices of DWA, these data are not, as a rule, shared with the users. In addition, the DWA staff do not regard themselves as accountable to the users. Most of the hydrological data are uploaded to databases and are then rarely utilized meaningfully or disseminated outside the institution. However, there seems no legal impediment or reason in the NWA to prevent monitoring of the resource by the users or by agents accountable to the users. Once again, this is an institutional rather than a NWA problem, and again requires an intervention:

INTERVENTION 5: Create institutional policies that allow for, encourage and empower WUAs to monitor the status of their groundwater resource.

5 Graduated Sanctions – *'Sanctions for rule violations start very low but become stronger if a user repeatedly violates a rule.'*

Sanctions of any kind, graduated or not, are currently very rarely encountered in a WUA or other water institution in South Africa. There are no signs that this situation is going to change in the future. However, there is nothing in the NWA to prevent such sanctions. Thus the following intervention is required:

INTERVENTION 6: Create institutional policies that allow for, encourage and empower WUAs to impose graduated sanctions.

6 Conflict-Resolution Mechanisms – *'Rapid, low-cost, local arenas exist for resolving conflicts among users or with officials'*

Local disputes often get delegated upwards to institutions like DWA, where management of the disputes usually drags on for years, with little prospect of resolution. While the direct costs may be minimal, the indirect costs – because of

the time factor – can be excessive. As with many other design principles, there is nothing in the NWA that prevents this, but there may be strong institutional resistance to the approach. Again, an intervention is therefore required:

INTERVENTION 7: Create institutional policies that allow for, encourage and empower WUAs to resolve conflicts using rapid, low-cost approaches.

7 Minimal Recognition Of Rights – *'The rights of local users to make their own rules are recognized by the government.'*

As with design principle 3, the NWA permits (to a degree) ' minimal recognition of rights'. The right of local users to make their own rules is recognized by government, provided these rules are not about water management. A WUA has no right to make rules about water management, although these rules may be delegated to it. Making its own rules about water management is therefore a privilege, not a right.

The NWA (RSA 1998) explains the role of WUAs as follows: ***'Although water user associations are water management institutions their primary purpose, unlike catchment management agencies, is not water management. They operate at a restricted localized level, and are in effect co-operative associations of individual water users who wish to undertake water-related activities for their mutual benefit. A water user association may exercise management powers and duties only if and to the extent these have been assigned or delegated to it.'***

It is therefore argued that the right to make its own rules about water management requires a change to the NWA and not just institutional policy. Without this change, it will remain a privilege – and being granted this privilege will remain option for the authorities, with very little to support the case that this option would ever be used.

INTERVENTION 8: Amend the NWA so that WUAs have the right to do water management, instead of it being a privilege that they may or may not be granted.

8 Nested Enterprises – '*When a common-pool resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers.'*

There are many institutions besides the DWA that take into account the use of and impacts on water resources. The Department of Agriculture, The Department of Mineral and Energy Affairs, and The Department of Environment are three examples. DWA attempts to get the inputs of WUAs regarding a variety of issues. The nesting of these multiple layers might not be ideal and might not be very effective, but the basics of polycentric governance do exist. There appears no rational reason why these polycentric arrangements cannot be improved in the future.

However, while existing polycentric governance arrangements might not be ideal, it is clear that they already exist. This indicates that there is nothing preventing linkages regarding this design principle. Therefore no interventions are required.

5.3.3 CAN THE DESIGN PRINCIPLES GIVE EFFECT TO THE AIMS OF THE NWA?

The main aims of the NWA are sustainability and equity, although the NWA (sensibly) does not try to specifically define sustainability and equity. Much has been written on the topic of sustainability and what it means. For the purposes of groundwater sustainability, Llamas et al. (2007) provide a good introduction to the topic, and define nine aspects of sustainability: Hydrological, Ecological, Economic, Social, Legal, Institutional, Inter-generational, Intra-generational, and Political. Intra-generational sustainability appears equivalent to equity in scope. Earlier, it was argued that groundwater governance is essentially an attempt to reconcile all these different facets of 'sustainability.' Farmers, ecologists, social engineers, and hydrogeologists might have interpretations of sustainability for every aquifer system. There is no 'right' or generic answer to these diverse requirements. Local negotiations to pursue unique, local solutions are necessary.

The design principles can accommodate local negotiations, and can even be regarded as a way to optimize these negotiations. However, there is a concern that a WUA, created around a community of interest, will focus on its interest – for example optimal economic gain from a groundwater resource – and neglect broader societal aspects of sustainability.

Design principle 8 (nested enterprises) could accommodate this concern if the broader societal aims were somehow fed into the WUA via nested hierarchies, but by no means guarantees that this would happen. It is suggested that one way of ensuring that broad societal aims are considered by groundwater WUAs is for representatives from higher/external institutions that represent a specific aspect of sustainability to be accorded WUA user membership. These representatives would then be 'agents' for the specific water 'use' they represent – e.g. non-consumptive use for aquatic ecosystems, and would thus be allowed to participate in and vote on WUA matters. According to Thompson (2005) such a broad definition of water user is permissible: any interested and/or affected party could theoretically be allowed to be a member of a WUA, and not just those that are direct, consumptive users.

The aforementioned example of possible implementation strategies shows that WUAs operating according to the design principles could accommodate broader societal aims, but would not automatically do so. Therefore it is suggested that the processes for taking these broader societal aims into account would have to be made explicit in national and catchment water and groundwater strategies.

INTERVENTION 9: Institutional policies to ensure that WUAs integrate broader societal aims and do not just focus on consumptive use.

5.4 Linking Good Groundwater Governance To [Non-Local] Institutions

5.4.1 INTRODUCTION

'Non-local' implies every organisation that covers a larger area than a WUA. CMAs and the national DWA are the main default institutions considered in this investigation since they are the primary institutions responsible for water management at the 'larger than WUA scale'. South Africa's Groundwater Strategy

(GWS) (DWA, 2010) contains consensus-based strategies 'designed to ensure that groundwater is recognised, utilized and protected as an integral part of South Africa's water resource.' The GWS is therefore used as the primary reference document for non-local institutions. Text Box 3 summarizes what the GWS identifies as the actions required to improve institutional capacity.

- Capacitate and provide adequate resources to the Regional Offices to fulfil their mandatory water resource management functions.
- Support and if necessary re-establish Water User Associations to improve the local management of groundwater resources.
- Redefine the roles and responsibilities for groundwater development and management within the constraints of limited capacity across both water resource management and water services institutions. This should include monitoring of groundwater level abstraction and quality as well as the maintenance and operation of groundwater infrastructure across sectors (i.e. water resource management, the environment and water services).
  - Improve and streamline the coordination of water resource management and water services functions across the various institutions.
  - Produce a simple flowchart showing 'who is responsible for what' groundwater management functions.
  - Establish a platform within Regional Offices for the coordination of groundwater activities.
- Improve cooperation between government departments and the private sector to leverage available capacity and resources.
  - Coordinate with governmental departments such as DEA, parastatals and the private sector to utilize available capacity and resources.
  - Improve the coordination of functions between the directorates of water resource management and water services within the Regional Offices to optimally utilise limited capacity and resources.
  - Provide strategic support to water services institutions to develop business plans (i.e. WSDPs) for groundwater development, management and monitoring as well as for the operation and maintenance of groundwater infrastructure.
  - Formal communication channels between DWA offices and other water management institutions (such as water service providers or water user associations) must be established, or improved where they exist.
  - Consider public-private partnerships to manage major aquifer systems as well as to address significant impacts associated with large-scale abstractions, pollution, mine water decanting and regional mine closure programmes.
- Incorporate the recommendation from the Reconciliation Strategies into the IDPs and WSDPs.
- Strengthen support for collaboration with institutions from other countries, e.g. SADC based IWRM post-graduate training programmes, sector partnerships, bi-lateral aquifer management committees, etc.

Text Box 3. Institutional Capacity 1 – Actions identified by GWS

The majority of GWS is devoted to improving groundwater management, and therefore, by implication, groundwater governance. However, an explicit definition of good groundwater governance is not contained in the strategy. Therefore – as with the good governance – NWA linkage – it is assumed that if the ODP are being met then good groundwater governance will be taking place. For the purpose of this project, investigating the linkages between non-local institutions and the definition of good governance is synonymous with testing the linkages between non-local institutions and the ODP.

To investigate these linkages, two questions were asked:

1) Can the ODP in general be implemented by the GWS?
2) Are the specific requirements in the design principles that require a specific plan in the GWS?

5.4.2 CAN THE OSTROM DESIGN PRINCIPLES IN GENERAL BE IMPLEMENTED BY THE GWS?

Text Box 2 lists the key actions required by the GWS. It can be seen that most of these actions are generic and therefore there is nothing that specifically precludes the ODP. It could therefore be argued that the ODP are permissible in terms of the GWS. However, there is nothing in the GWS that mentions or is a precursor to the design principles. Therefore, even though the design principles are permissible in terms of the GWS it seems highly improbable that they would ever be considered unless they were specifically mentioned. An intervention is therefore required:

INTERVENTION 10: Include a commitment to the Ostrom Design Principles in the GWS.

Policy, Legislation and Regulation:

All groundwater water use license applications must be resolved within six months.
All larger groundwater users must be registered and possess water use licenses.
Existing groundwater use must be verified within a reasonable time period.
Borehole drillers must be registered with the Department, and must submit drilling and test pumping data to the Department from all boreholes drilled.

Water Resources Planning:

Conduct groundwater resource assessments to a level comparable with other water resource assessments (e.g. assessment of surface water potential).
Implement groundwater development programmes for domestic and productive water use to support national imperatives.
Update figures on groundwater availability and use as new data becomes available.
Establish guidelines for the groundwater content of Internal Strategic Perspectives and emerging catchment management strategies.
Develop and implement best practise guidelines on groundwater management and protection for the municipal, agricultural, energy and forestry sectors.

Human Capacity:

Develop adequate capacity to fulfil the groundwater functions.
Develop and implement a national capacity building strategy.
Mobilise private sector support where necessary to capacitate Regional Offices.
Implement practical, in-service training courses on priority aspects (e.g. licensing process, the Reserve, groundwater monitoring, etc.) for staff.

Sustainable Groundwater Management:

Ensure the implementation of existing strategies, regulations and guidelines on groundwater management such as the Artificial Recharge strategy and others.
Establish a Groundwater Resource Governance Section, which will ensure support to water services institutions in the operation, maintenance and management of groundwater supply schemes. Functions must include the evaluation of artificial recharge potential and conjunctive use schemes.

Institutional Capacity:

Capacitate and provide adequate resources to the Regional Offices to fulfil their mandatory water resource management functions.
improve cooperation and coordination within the Department, and between government departments and the private sector to leverage available capacity and resources.
Incorporate the recommendations from the Reconciliation Strategies into the Integrated Development Plans (IDPs) and Water Services Development Plans (WSDPs).
Provide strategic support to water services institutions to develop business plans (i.e. WSDPs) for groundwater development, management and monitoring as well as for the operation and maintenance of groundwater infrastructure.
The roles and responsibilities for groundwater development and management, including monitoring of groundwater level abstraction and quality, as well as the maintenance and operation of groundwater infrastructure across sectors should be improved and streamlined, and responsibilities clearly defined.

Information Management:

Announce the National Groundwater Archive (NGA) to the Public Domain, including Catchment Management Agencies (CMAs), water resources and other external stakeholders, as well as finalize the adoption of measures to incorporate privately held datasets, including the registration of drillers.
Develop and implement an integrated groundwater information system to support water services provision at municipal level.
Develop and implement a Groundwater Monitoring Strategy to address the monitoring challenges at national and regional level.

Groundwater Research:

The Department and the Water Research Commission (WRC) must continue to support groundwater research capacity at tertiary institutions, and prioritise research projects which directly address strategic national objectives, including issues identified as bottlenecks in groundwater management or delivery.
Dissemination and implementation of research products must be improved.
Water Research Commission (WRC) should regularly assess the impact of research investment in groundwater.
Emphasis should be placed on the strategic leveraging of resources between the WRC, DWA, National Research Foundation (NRF) and the alignment of strategic objectives for groundwater management between the WRC and DWA, e.g. the development and roll-out of strategies supported by implementation programmes.

Communication and Awareness:

- Develop a professional marketing and communication plan focussing on promoting successful groundwater use and management.

Text Box 4. Summary of GWS key focus areas

5.4.3 ARE THERE SPECIFIC REQUIREMENTS IN THE DESIGN PRINCIPLES THAT REQUIRE A SPECIFIC PLAN OF ACTION IN THE GWS?

Only ODP 3, 7 and 8 require either an explicit action from higher levels of government, or an implicit, tacit acknowledgement of some aspect of a WUA's rights and responsibilities. The actions listed under each intervention were already identified in section 3.3.2 so as to link the ODP to the NWA.

3 Collective-Choice Arrangements – '*Most individuals affected by a resource regime are authorized to participate in making and modifying its rules.'*

-> INTERVENTION 3: Create institutional policies that allow for, encourage and empower WUAs to make their own water management rules (see Section 3.3.2)

7 Minimal Recognition Of Rights – *'The rights of local users to make their own rules are recognized by the government.*

-> INTERVENTION 8: Amend the NWA so that WUAs have the right to do water management, instead of it being a privilege that they may or may not be granted (see Section 3.3.2)

8 Nested Enterprises – '*When a common-pool resource is closely connected to a larger social-ecological system, governance activities are organized in multiple nested layers.'*

-> no intervention required (see Section 3.3.2)

It is suggested that interventions 3 and 8 are equally relevant to linking the ODP to non-local institutions, since they require institutional intervention in both cases. However, in the case of Ostrom design principle 8 (Nested Enterprises) although it was argued that no interventions were required under the good governance (ODP – NWA linkage), in this case it is argued that a specific intervention is necessary to properly link the ODP to non-local institutions. This report has already discussed that polycentric forms of governance are evolving naturally in South Africa and that as a result of this natural evolution there is no need to address this from a NWA perspective. However, it has also been discussed that these polycentric forms of governance are far from ideal. It is therefore argued that there is a need for a GWS intervention to actively support polycentric governance:

INTERVENTION 11: Foster, encourage and the support of local groundwater governance via polycentric governance and nested enterprises.

5.5 Linking Good Groundwater Governance To Hydrogeological Science

The definition of groundwater governance proposed by this project makes no explicit demands of science, since it is primarily about decision-making processes. It is therefore assumed that the ODP will provide the necessary general requirements for good groundwater governance and hydrogeological science to be linked. Very few of the ODP make any specific requirement of science since the design principles are also primarily concerned with the governance process rather than specifications about science. However design principles 1B and 2A do imply some scientific requirements:

Design Principle 1B. Resource Boundaries: '*Clear boundaries that separate a specific common-pool resource from a larger social-ecological system are present.*'

Design Principle 2A. Congruence with Local Conditions: '*Appropriation and provision rules are congruent with local social and environmental conditions.*'

In Principle 1B, the groundwater boundaries could be an aquifer or aquifer unit. South Africa has hydrogeological maps and significant knowledge of the main aquifer systems in the country. Although there is always room for improvement in this knowledge, it is argued that enough is known about groundwater occurrence in South Africa that the link between Design Principle 1B and hydrogeological science is already in place in South Africa. Thus an intervention is not needed in this case.

However the link between Design Principle 2A and the practice of hydrogeological science in South Africa is not so clear. The Principle appears to be saying that whatever rules science provides, they should fairly reflect the physical environmental conditions and also the prevailing local, social culture.

'The first condition (2A) is that both appropriation and provision rules conform in some way to local conditions; Ostrom emphasizes local conditions of the CPR, such as its spatial and temporal heterogeneity.

..... the literature predominately reflects Ostrom's emphasis on an institutional congruence with the resource condition, in line with the Spanish irrigation case she discusses. For example, Guillet (1992:104) describes practices in Peruvian irrigation systems: "Under normal conditions farmers are given water sufficient to cover the requirements of their fields, a proportional allocation with Inka antecedents... when water scarcity threatens, this principle is modified and actions are taken to ensure that each household has access to a subsistence minimum."

Some scholars have also identified local conditions as involving the predominant culture, ideology, customs, and livelihood strategies of a community (Morrow and Hull 1996, Young 2002, Gautam and Shivakoti 2005). Other authors have highlighted the negative consequences that result when externally imposed rules do not match local customs and livelihood strategies. For example, Gautam and Shivakoti (2005) observed that the rules designed by the Dhulikhel municipality imposed a total ban on the harvest of forest products and that these rules did not match the resource conditions and contradicted customary rules of villagers, who had traditionally allowed activities such as the collection of leaf litter for animal bedding and fallen twigs for firewood. In turn, the effectiveness of monitoring and compliance with rules was very low, and the forest had come under high extraction pressure. Morrow and Hull (1996) studied a donor-initiated forestry cooperative in the Palcazu Valley of Peru and came to similar conclusions regarding the need for this internal-external type of congruency.'

Text Box 5. Discussion of design principle 2A (Cox et al., 2010)

The overall message from this dissection of rule 2A by Cox et al. (2010) appears to be that rules of allocation, if governance sustainability is to be ensured, must make sense and be fair. If the availability to harvest any resource varies spatially then the rules must take this into account. If the availability of a resource varies with time, then the rules must be flexible enough to accommodate this. The users must broadly accept the rules for allocation and they should not be seen to favour one individual or group.

In the South African groundwater governance situation this means that allocation and provision rules must match *local* variations in spatial and temporal availability.

At the moment this is not the case. Rules are based on *regional* water balances, with little regard for local geographical or spatial variations in availability.

In South Africa groundwater use may be regulated by:

- Licensing.
- General authorisations.
- Permissible continuation of existing lawful use.
- Schedule 1 use – this includes reasonable domestic use, non-commercial small gardens, and stock water (excluding feedlots).

The rationalisation for the regulations is that Schedule 1 use would have no or minimal impacts; use controlled by general authorisations would have low risk of impacts; and that a licence is only needed when there is a high risk of impacts. In other words the licensing process is only used when there is a risk that 'sustainability limits' might be exceeded.

For each licence application, the DWA national office makes an estimate of the recharge, and the Reserve. The ecological component of the groundwater Reserve is normally based on estimates of in-stream flow requirements (IFR) needed to maintain aquatic ecosystems, using the assumption that the maintenance low-flow component of IFR can be met by base flow from groundwater.

Once the Reserve has been determined, the relevant DWA regional office then decides whether to recommend, or not recommend, the licence application, and what conditions to apply, based on recharge, the Reserve, the quantity required by the licence, existing use, and any other relevant factors. At this stage the normal procedure is to 'do a water balance'. The Reserve and existing lawful use are subtracted from recharge. If a difference between the two remains, and this quantity exceeds the licence application, it is assumed there is enough water available, and the licence application is (normally) recommended.

Seward et al. (2006) have argued that, conceptually, this approach is wrong. The increased abstraction by the licensee has to be met by the capture of discharge, recharge, storage or a combination thereof. Capture might include:

- A reduction in groundwater's contribution to base flow.
- Drying-up of springs.
- Reduced yields from boreholes on adjacent properties.
- Terrestrial vegetation dependent on groundwater dying.
- Capture of water from surface bodies such as rivers flowing through the area.
- Capture of groundwater from adjacent aquifers and aquifer systems.

Allocating groundwater using a water balance approach has received much criticism even though is remains the de facto approach in many cases. The water balance approach essentially involves calculations and monitoring so as to 'pump-the-recharge' (Balleau, 2013). It seems so intuitively obvious that 'what is taken out' of an aquifer should be, and can be limited to 'what goes in' that alternative ways of approaching the problem have encountered much resistance. However, 'pumping-

the-recharge' creates serious problems because it (a) ignores the spatial and temporal aspects of sustainability (Theis, 1940; Bredehoeft, 2002); (b) does not encompass the whole range of sustainability benefits and consequences (Kalf and Woolley, 2005; Pierce et al., 2013), (c) it is not even an indicator of the sustainability of any particular benefits/consequences option (Seward et al., 2006), and (d) fuels the misconception that there is a single, numerical answer to sustainability (Balleau, 2013; Rudestam and Langridge, 2014).

Existing approaches to this problem are (a) attempting to solve it by using the capture principle instead of natural recharge as the conceptual basis for monitoring, modelling, and adaptive management (Bredehoeft, 2002; Maimone, 2004), (b) disputing that there is a problem (Zhou, 2009), and (c) ignoring it (Balleau, 2013).

Since appropriate science to describe appropriate local groundwater conditions is so crucial to this design principle, an extended discussion will be provided here.

It needs to be emphasized that groundwater sustainability has strong spatial controls. Spacing between wells, depths of wells and proximity to the recharge zone will determine how much water can be taken out of an aquifer (Thomas, 1951). Proximity to existing wells, wetlands and streams will determine the extent of the consequences of utilizing new wells. These spatial effects are explained by the capture concept (Lohman et al., 1972), whereby water sustainably pumped from wells is matched by reduced discharge and/or increased recharge (Theis, 1940).

A spatial approach to groundwater management using well-spacing is not uncommon in developing countries where local communities have chosen to manage their groundwater resources themselves (Foster et al., 2000; Van Steenbergen, 2006; Taher et al., 2012). Typical well-spacing distances can range from 250 m to 1 km. Spatial approaches are also used in developed countries. Nearly all the western states of the USA, where groundwater is treated as private property, have some form of well-spacing regulation (Gardner et al., 1997), and the well-spacing can range from 100 m or less in some counties in Texas to 6 km in parts of Dakota (Brozowic et al., 2006).

These spatial approaches are primarily focused on distances between wells rather than distances to natural recharge or discharge areas. However, these spatial approaches do take capture into account by making estimates of the likely extent of the cone of depression. While well-spacing does not appear to be effective in addressing intensive groundwater use in the Great Plains Aquifer, USA (Gardner et al., 1997; Sophocleous, 2010), there are several examples from countries such as Yemen where local communities are effectively managing groundwater use using a well-spacing approach (Van Steenbergen, 2006; Taher et al., 2012). Indeed, current thinking on groundwater governance (Taher et al., 2012, Wijnen et al., 2012) advocates using simple rules that can be practically monitored, where rule violations can be practically detected and enforced, rather than using rules that are difficult to determine scientifically, difficult to monitor and difficult to enforce. Taher et al. (2012) rank spatial methods as the first and third most useful variables to meet these challenges while quantity allocations – the de facto approach in many countries – were ranked 19th out of 22.

According to Brozowic et al. (2006) well-spacing regulations have been entirely ignored in the economic literature, even though well-spacing, in some conditions, might be more effective and appropriate than (volumetric) quotas. Katic and Grafton (2012) argue that spatial regulations could also provide excellent controls either by themselves or in conjunction with extraction controls, and that well-spacing regulations could provide substantial welfare gains even if extraction rates are unregulated. However, the pervasive paradigm for groundwater management is a volume-based approach, typically using quotas assigned by permits (López-Gunn, 2003; Mukherji and Shah, 2005; Feitelson, 2006; Llamas & Garrido, 2007; Seward, 2010; Wester et al., 2011; Mechlem, 2012; Wijnen et al., 2012), with well spacing used as an adjunct, if at all.

The yield-based approach almost invariably resorts to 'pumping the recharge' determinations (Balleau, 2013) rather than use the capture principle. Part of the reason for this could be that a large part of the hydrogeological community does not believe there is anything wrong with using natural recharge for aquifer and hydrological sustainability. Zhou (2009) argues that it is a misconception that aquifer sustainability depends totally on either natural recharge or on capture, and that the reality is that aquifer sustainability depends on both processes. However, the basis for Zhou's (2009) argument for including recharge is the special case where there is no induced recharge caused by pumping. In this case natural recharge to a basin equals the sum of all the discharges (natural or human-induced) and the total pumping from the basin cannot exceed the natural recharge. While this may be of value in theoretical comparisons of one basin with another, it gives no practical indication of aquifer sustainability for a particular well or well-field within a given basin. In addition, it is not clear how it can be known in advance that there will be no induced recharge caused by pumping within a certain basin, and that aquifer sustainability could not be greater than natural recharge. If the recharge zone(s) were located, wells drilled in these zones, and the water levels significantly lowered, it is difficult to see how recharge would not be affected.

Another argument is that even if using capture is theoretically preferred to natural recharge for determining aquifer sustainability, it is just too impractical to implement (Vivier, 2013). Indeed Lohman (1972) advocates not putting a number on aquifer sustainability in the early stages of development. The argument is (Vivier, 2013) that a water balance is needed to determine whether or not additional groundwater development is feasible, and to determine at least an initial pumping rate as part of an adaptive management strategy. The counter argument is that borehole densities based on capture zones could provide as good, or a better, indication of the room for additional development, and that well yields derived from pumping test provide a much better indicator of initial pumping rates than a percentage of natural recharge.

Another possible reason for the preference for managing groundwater volumetrically rather than spatially is because that is what legislators and water managers expect. Rudestam and Langridge (2014) describe how hydrogeologists and water managers in the state of California are essentially obligated to 'pin' groundwater sustainability down to a specific number even though the nature of groundwater sustainability makes this impossible. This obligation does not appear to

be restricted to California. A directive, for example, that pumping should be limited to 1 097 632 m^3/year does, on casual inspection, *seem* a lot more authoritative, precise and scientific than a 'messy' directive to not to pump in zone A, not to pump in zone B, stay more than a km from the nearest well, with no limits on pumping quantities in the remaining areas. However the 'messy' directive will actually be more precise in preventing unacceptable impacts if it takes cognizance of the capture principle, and if the 'precise' directive is based on a water balance.

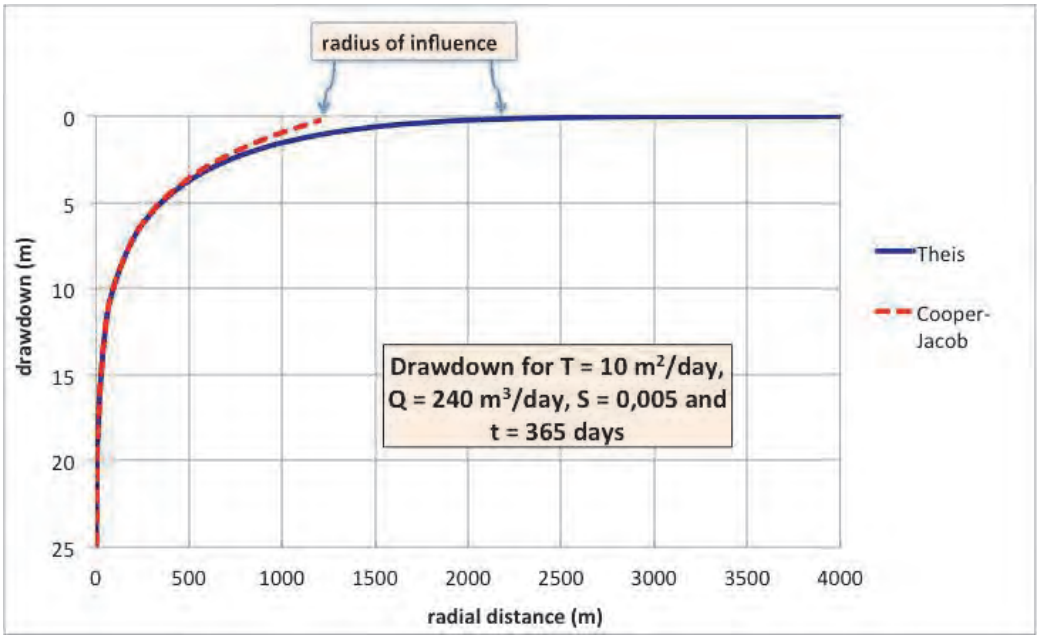
It is evident that there is not a lot of trust within the hydrogeological community on the appropriate hydrogeological science to use in local groundwater governance situations. It also seems clear/likely that other local groundwater governance stakeholders may also not totally trust and/or have unrealistic expectations as to what hydrogeological science can deliver. An intervention is therefore needed to address this issue:

INTERVENTION 12: Develop hydrogeological science methodologies that are robust to spatial and temporal variations under local conditions, and are broadly accepted by all participating stakeholders.

One possible way of approximating radial distance is the following calculation: $r = 1.5(Tt/S)^{0.5}$. Under radial flow conditions, after a 'sufficiently long' pumping time the Theis radial flow equation simplifies with reasonable accuracy to (Cooper and Jacob, 1946) $s = (Q/4\pi T)\ln(2.25Tt/r^2S)$, where s = drawdown, Q = pumping rate, T = transmissivity, r = radial distance, S= storage, t = time. In practice 'sufficiently long' may mean an hour of pumping or less (Kruseman and De Ridder, 1994). The radial distance at which s, drawdown, in the Cooper-Jacob equation equals zero is then given by $r = 1.5(Tt/S)^{0.5}$, and can be used to calculate a so-called 'radius of influence.' However the 'radius of influence' will increase with time (Fig. 1) according to the Cooper-Jacob equation, and according to the Theis equation (Theis, 1935) is infinite.

Whether or not simple radial flow approximations such as $r = 1.5(Tt/S)^{0.5}$ can be satisfactorily used needs more empirical research. However, given the importance of spatial factors in local groundwater occurrence, it is clear that such research is needed:

INTERVENTION 13: Research into the value of $r = 1.5(Tt/S)^{0.5}$ and other simple indicators for predicting spatial impacts with sufficient accuracy.



Text Box 6. Radius of influence approximation for a pumped well

5.6 Linking Good Groundwater Governance To Local Institutions

5.6.1 INTRODUCTION

The previous sections have discussed ways to create an environment where good local groundwater governance can be fostered and maintained. This section deals with the more problematic part – how to practically connect the support to the local level so that the local level benefits from the support instead of the 'support' being self-contained and residing only in the hands of the 'supporters.' The supporting environment is essentially one where the ODP have been embedded in the science, laws and [national] institutions concerned. Rather than try to link science, laws and national institutions individually to each local study, science, laws, and national institutions are lumped together under the generic term of 'support.'

Thus, this linkage essentially involves the 'support' structures 'importing' the ODP to the local scale. Unfortunately, there is very little evidence of this ever being done, either in the groundwater field or any other CPR field. The 'design principles' refer to rules that happened to work and arose organically, not rules that were engineered or consciously imposed on a system. As a result, there is essentially no empirical evidence regarding effective ways of effectively 'planting' these rules from an outside organisation, and there is no obvious way of implementing or creating this linkage.

Occasionally there is evidence of a WUA-type organisation being formed by a charismatic local individual but in most cases groundwater WUAs appear to have evolved organically, sometimes from an existing water institution, and sometimes from non-water institutions. This does not prove local groundwater governance cannot be created by a top-down approach. However, caution should be exercised in assuming a top-down approach will work. Before this approach or system is

implemented, the mechanisms to make local governance work need to be fully analysed and understood.

It is for these reasons that Ostrom's thoughts on how to implement the design principles will be briefly reviewed before tackling the specifics of the South African situation. The following salient quotes (Text Box 7) attempt to provide general perspective and background on what would be required if the ODP were to be applied at the local level.

DESIGNING COMPLEXITY TO GOVERN COMPLEXITY (Ostrom, 1995)

'An overemphasis on the need for large-scale institutional arrangements can lead to the destruction or discouragement of institutional arrangements at smaller to medium to scales.'

'Any regulative system needs as much variety in the actions that it can take as exists in the system it is regulating.'

'Defining the boundaries of the resource and of those authorized to use it can be thought of a 'first step' in organizing for collective action.'

'Uniform rules established for an entire nation or larger region rarely can take into the account the specific attributes of a resource that are used in designing rules-in-use in a particular location.'

*'The problem of gaining compliance to rules – no matter what their origin – is frequently assumed away by analysts positing all-knowing and all-powerful **external** authorities that enforce agreements. In many long-enduring resources, no external authority has sufficient presence to play any role in the day-to-day enforcement of the rules-in-use.'*

'In long-enduring institutions, monitoring and sanctioning are undertaken primarily by the participants themselves.'

'When appropriators design at least some of their own rules, they can learn from experience to craft enforceable rather than unenforceable rules.'

'Appropriators frequently devise their own rules without having created formal, government jurisdictions for this purpose. But if external government officials presume that only they can make authority rules, then it is difficult for local appropriators to sustain a rule-governed resource over the long run.'

'Efforts to implement national legislation that would establish a uniform and detailed set of rules for an entire country are likely to fail in many of the ecological niches most at risk.'

'.... the costs of monitoring and sanctioning rule infractions at a local level are lower than the costs of doing all monitoring and sanctioning from a national level.'

'Local organizations operating alone frequently cannot access the kind of information essential to sustainable management.'

'If all local communities were to have to develop their own scientific information about the physical settings in which they were located, few would have the resources to accomplish this.

'Putting all of one's faith in very large-scale organizations does not protect future generations from failures of organisations to achieve sustainable use patterns.'

'The problem we face is not pitting one level of organization against another as a solitary source for authoritative decisions. Rather, the problem is developing institutional arrangements at multiple levels that enhance the likelihood that individual incentives lead participants towards sustainable uses of biodiversity rather than imprudent uses.'

Text Box 7. Designing Complexity to Govern Complexity

While these quotes help set the tone for what would be required for local governance (regarding what should and should not be done), they offer little practical advice on how to proceed with implementation.

5.6.2 OSTROM DESIGN PRINCIPLES AND LOCAL CASE STUDY OVERVIEW

The most obvious intervention strategy would simply be to implement the ODP that are missing. A cursory study of the three local areas with the ODP applied (Table 8) shows that most of the design principles are missing. The reasoning behind each region's design principle 'scorecard' will be briefly discussed, and then the implications for an intervention strategy will be assessed.

Table 8. Ostrom Design Principles present in the local case studies

OSTROM DESIGN PRINCIPLE	*Northern Sandveld – WUA*	*Hermanus – Monitoring Committee*	*Cape Flats – concerned parties*
1A. User Boundaries:	✔	partial	✖
1B. Resource Boundaries:	✔	✔	✔
2A. Congruence with Local Conditions:	✖	✖	✖
2B. Appropriation and Provision:	✖	✖	✖
3. Collective-Choice Arrangements:	✖	✖	✖
4A. Monitoring Users:.	✖	✖	✖
4B. Monitoring the Resource:	✖	✖	✖
5. Graduated Sanctions:	✖	✖	✖
6. Conflict-Resolution Mechanisms:	✖	✖	✖
7. Minimal Recognition of Rights:	✖	✖	✖
8. Nested Enterprises:	✔	✔	✔

In all three study areas the hydrogeology is known well enough to be able to delineate resource boundaries with reasonable confidence. However, the user boundary is only well defined in Northern Sandveld. Here the user boundary is determined by membership of the WUA. The issues in the Northern Sandveld are the extent of groundwater use for the irrigation of potatoes, and potential conflicts between allocations of groundwater for agricultural, municipal, or ecological use.

While the Hermanus Monitoring Committee has a semi-permanent nucleus of interested and affected parties, there appears to be no formal pre-requisites for being involved with the Monitoring Committee, and thus no means of excluding non-'users'. Again there are potential conflicts between municipal, agricultural and ecological use of groundwater.

Since the Cape Flats currently has no formal or informal users' organisation, it is impossible to delineate membership of a users' organization. All the inputs regarding the Cape Flats appear to come from concerned and interested, but not directly affected, parties such as academic institutions. The Cape Flats issues appear to be as much about land as they are about water (whether the land should be used for irrigating cash crops or whether it should be used for urban development). There is

also a body of opinion that the Cape Flats groundwater could be used for municipal use.

In all three cases some form of network linking with higher and other organizations does exist.

The preceding paragraphs have briefly reviewed the current status of local groundwater governance. To move from the status quo to a desired scenario using a backcasting perspective, requires that the following question be answered: how can the application of the ODP that are not currently being utilized be encouraged. To simply state that these principles need to be implemented is not very helpful. Therefore, the question is (and emphasis is on) *how*? The *how* is particularly important, given the limited capacity and centralized culture of the higher organisations involved.

How do EXTERNAL organisations help create LOCAL organizations that are largely autonomous? This is – in a sense – the nexus of the report.

If there is too much input, then the organisation will be dependent on the external organization and will never be sufficiently autonomous. If there is too little input the local organisation might never be created or sustained.

5.6.3 KEY ATTTRIBUTES FOR FORMATION OF SELF-GOVERNING ORGANISATIONS

To help address this question, Ostrom and others have identified a set of key attributes that are conducive to the *formation* of self-governing organisations. These are different to the design principles, which are about the *endurance* of self-governing organizations. The 'formation attributes' are introduced here with a view to narrowing down to a manageable level the conditions a higher organization might be willing or able to change so as to increase the likelihood that a local organization will be created.

The formation attributes are (Ostrom, 2005):

ATTRIBUTES OF THE RESOURCE

R1. Feasible improvement: Resource conditions are not at a point of deterioration such that it is useless to organize or so underutilized that little advantage results from organizing.

R2. Indicators: Reliable and valid indicators of the condition of the resource system are frequently available at a relatively low cost.

R3. Predictability: The flow of resource units is relatively predictable.

R4. Spatial extent: The resource system is sufficiently small, given the transportation and communication technology in use, that appropriators can develop accurate knowledge of external boundaries and internal microenvironments.

ATTRIBUTES OF THE APPROPRIATORS

A1. Salience: Appropriators depend on the resource system for a major portion of their livelihood or the achievement of important social or religious values.

A2. Common understanding: Appropriators have a shared image of how the resource system operates (attributes R1, 2, 3, and 4 above) and how their actions affect each other and the resource system.

A3. Low discount rate: Appropriators use a sufficiently low discount rate in relation to future benefits to be achieved from the resource.

A4. Trust and reciprocity: Appropriators trust one another to keep promises and relate to one another with reciprocity.

A5. Autonomy: Appropriators are able to determine access and harvesting rules without external authorities countermanding them.

A6. Prior organizational experience and local leadership: Appropriators have learned at least minimal skills of organization and leadership through participation in other local associations or learning about ways that neighboring groups have organized.

Application of these formation attributes to the three local case study areas lead to the results obtained in Table 9.

Table 9. Self-governance formation attributes for the three case studies

FORMATION ATTRIBUTE	Northern Sandveld	Hermanus	Philippi
R1. Feasible improvement	✔	✔	✔
R2. Indicators	✖	✔	✖
R3. Predictability	✔	✔	✔
A1. Salience	✔	✔	✔
A2. Common Understanding	?	?	✖
A3. Autonomy	( )	✖	( )
A4. Prior organizational experience and leadership	✔	✔	✔

It may seem somewhat illogical to apply the formation attributes to the Northern Sandveld WUA and the Hermanus Monitoring Committees since these bodies already exist. However, this comparison provides insights, especially since it shows that conditions for self-governance at Philippi are not significantly less favourable than in the other two case studies.

The number of formation attributes that are missing is far less than the number of design principles missing, suggesting that the conditions for the *creation* of a local groundwater governance association are more favourable than the conditions for

sustaining such an association. Thus *creating* an association seems at least 'do-able.' *Sustaining* that association and making it effective is far more of a challenge.

An in-depth evaluation of each case study area will now be conducted in order to identify the most feasible interventions for each area.

5.6.4 PHILIPPI – BACKGROUND

The Phillipi area is underlain by an aquifer that forms part of the Cape Flats Aquifer System (Figure 9). The hydrogeological properties of the Cape Flat Aquifer System have been studied since the 1970s (Gerber, 1976; Vandoolaeghe, 1989; Adelana et al., 2010). It was estimated (Wright and Conrad, 1995) that approximately 13 million m^3/year of groundwater was being abstracted by the Philippi farmers. The aquifer is comprised mainly of unconsolidated sand. The Philippi Horticultural Area (Fig. 10) covers some 3000 ha and lies over one of the most productive parts of the aquifer.

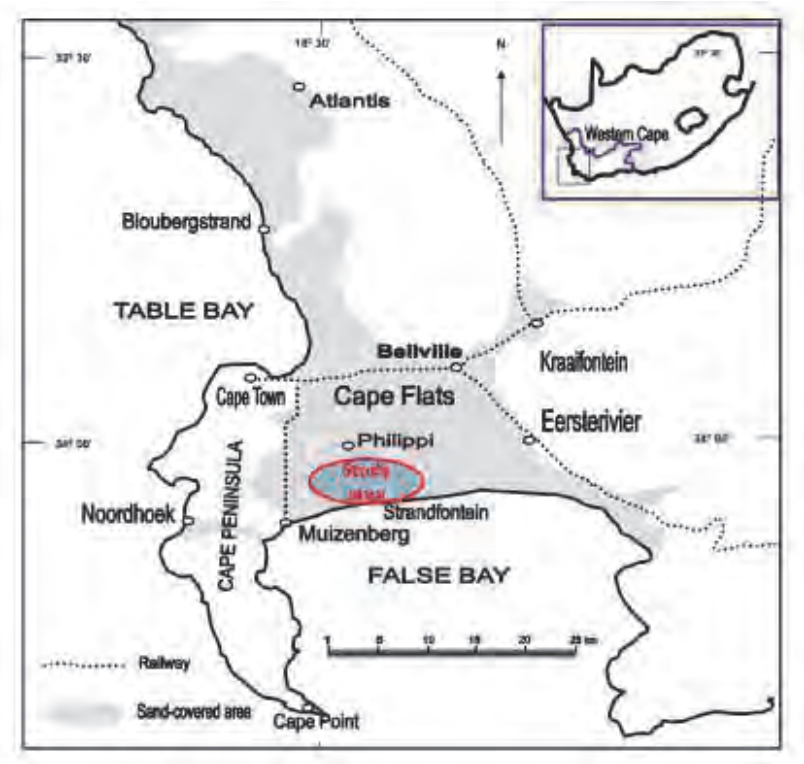


Figure 9. Philippi – Regional Setting

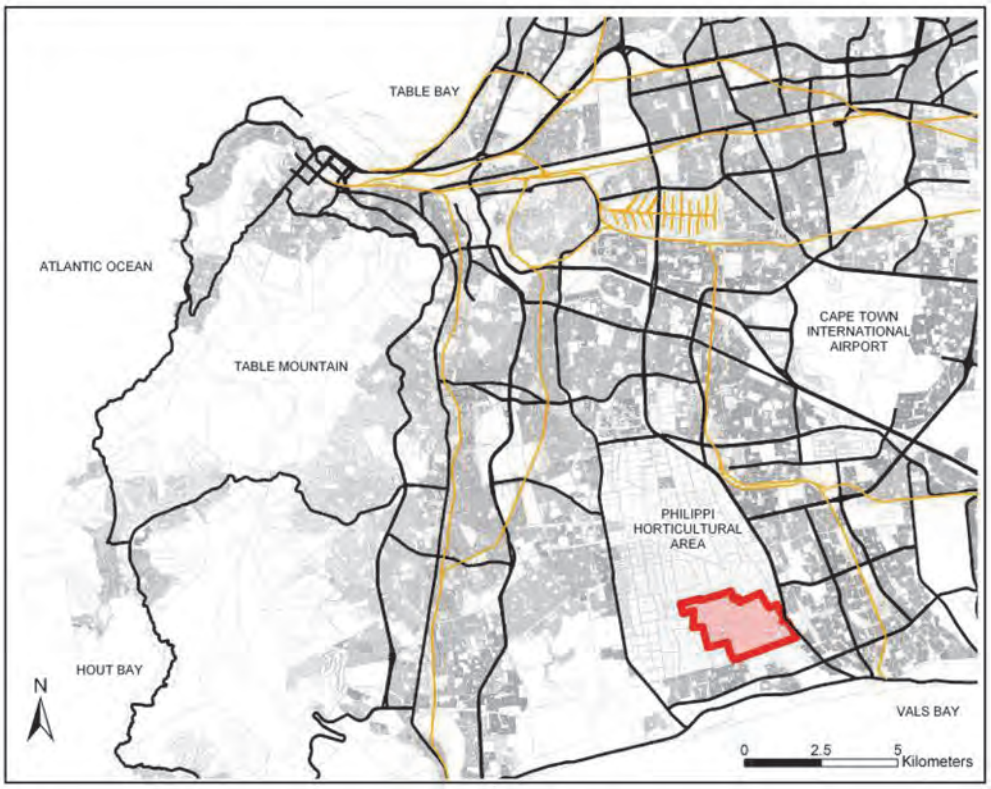


Figure 10. Philippi – Urban Setting

[The area in red was part of a recent rezoning application – from agricultural (Fig. 11) land to mixed residential/industrial.]

For the groundwater users, the issues are not primarily about groundwater but about land. Their main concern is that the land will be re-zoned. Secondary concerns include pollution from factories, informal housing, sand mining (Fig. 12) and illegal dumping. However, these concerns are used as additional motivation to protect their land. The users believe that groundwater monitoring is inadequate. The present study confirmed this viewpoint since DWA only monitors 3 boreholes in the area. However, the groundwater users do not regard groundwater monitoring as their responsibility (Sonday, 2014). The groundwater users/landowners expect free and unregulated access to public groundwater but do not regard this as a reason to participate in monitoring the resource.

Figure 11. Commercial Farming at Philippi

This situation presents an opportunity for a social entrepreneur to 'sell' to the appropriators the benefits that might be derived from doing their own monitoring. Monitoring groundwater levels and taking electrical conductivity readings is neither difficult nor exceedingly time-consuming. It cannot be more difficult than operating complex irrigation equipment. A possible compromise might be for academic or government institutions to physically do the monitoring as long as the institution(s) are *accountable* to the appropriators for the monitoring that gets done, i.e. the appropriators direct what monitoring needs to be done, get the results, and the implications. This is in contrast to the current scenario where external organisations such as DWA (a) *decide* on what monitoring should be done, (b) *do* the monitoring, and (c) *store* the data without analysing or sharing the data. The situation also offers a prime opportunity for hydrogeologists to explain the scientific benefits of monitoring and generally increase 'understanding.'

Figure 12. Wetland in an area previously used for sand mining

INTERVENTION 14: [Philippi] Social entrepreneur to motivate benefits of PHA doing their own monitoring.

INTERVENTION 15: [Philippi] Hydrogeologists from academic and state institutions to motivate benefits of PHA doing their own monitoring and to provide support where necessary.

5.6.5 NORTHERN SANDVELD

The Sandveld Water User Association was proclaimed on 27th July 2007. It covers drainage regions G30F and G30G (Fig. 13). Since groundwater is the principal source of groundwater in this area the Sandveld Water User Association is in effect a groundwater WUA. The main source of groundwater is unconsolidated sand aquifers. Groundwater is used to supply the towns of Lamberts Bay, Graafwater and Leipoldtville, but the main use of groundwater is by commercial farmers for irrigating potatoes (Fig. 14). Some scientists regard groundwater dependant ecosystems as the third major user of groundwater in the area. Prior to large-scale groundwater abstraction there was a combined spring flow of some 30 l/s at Wadrif. The springs have stopped flowing for more than two decades and the wetland associated with the springs destroyed. (Seward et al., 2006) Part of the reason for this depletion was municipal abstraction for Lamberts Bay municipal supply at the Wadrif well-field. However this in turn has been effectively depleted by irrigation from agriculture and Lamberts Bay has had to look for water supplies further inland. In round numbers, the towns in drainage regions G30F and G30G consume some 1 million m^3/year while irrigation for potatoes consumes an estimated 25 million m^3/year (Conrad and Munch, 2006).

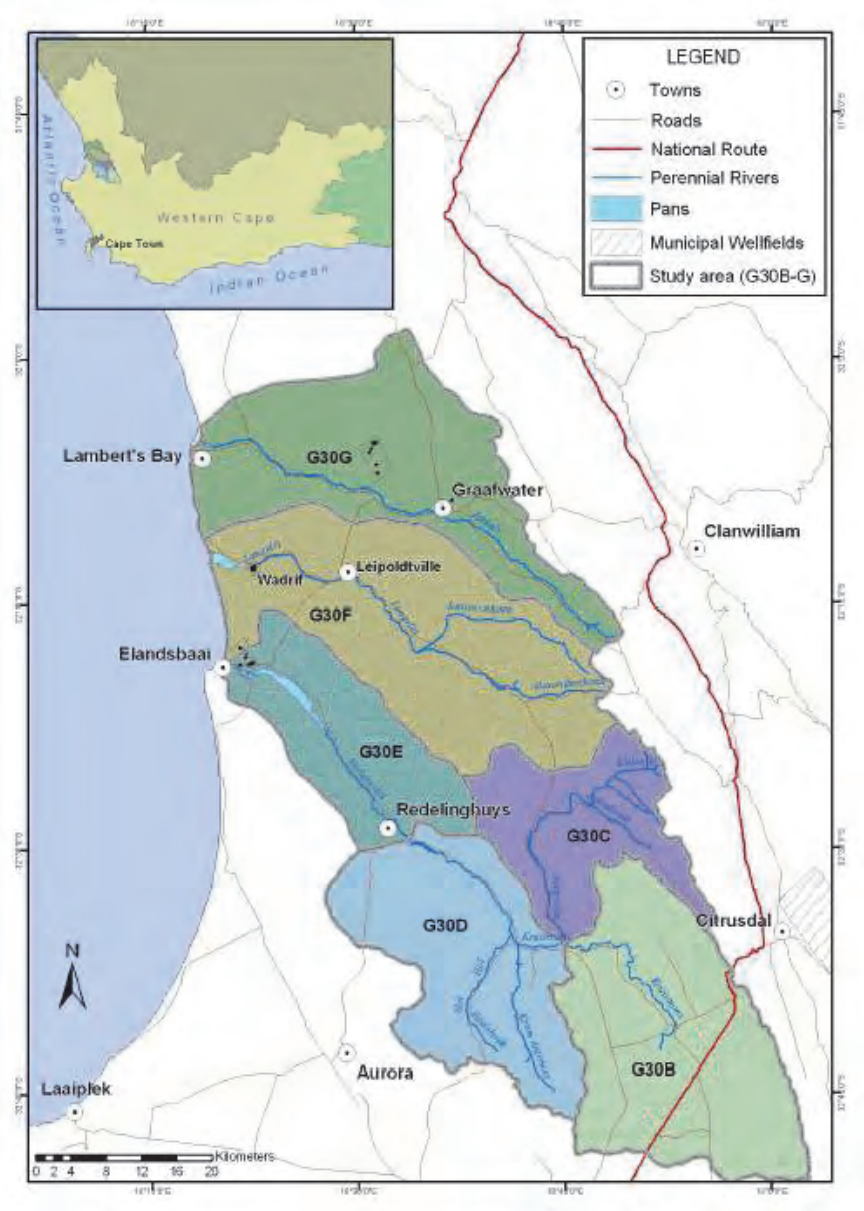


Figure 13. Northern Sandveld [location] (Conrad and Munch, 2006)

The aquifers in this area have been studied, delineated and quantified since the 1970s (Nel, 2005). DWA and other government bodies have also funded an extensive stockpile of reports since the inception of the 1998 National Water Act, mainly to do with management of the groundwater and its impact on associated ecosystems, but also to advance hydrogeological understanding. In addition DWA has monitored some 50 boreholes and other monitoring points in G30F and G30G over the past ten years or so.

Figure 14. Typical Northern Sandveld Landscape

The general consensus among hydrogeologists is that groundwater in this area is moderately to severely exploited. This consensus is based largely on water balance approaches. However, as Conrad and Munch (2006) pointed out, water levels tell a different story. For most of the area water level trends are approximately stable, suggesting that over-abstraction is a highly localized phenomenon.

The concerns of the hydrogeology community have, however, had no impact on groundwater use in this area, despite all the research and the reports generated and despite all the DWA monitoring, Reserve determinations (Text Box 8) and Management Plans. Interventions carried out by DWA and other higher institutions appear not to command attention or interest and have had little or no impact at the local level.

Dir: Resource Directed Measures

Chief Director: The Southern Cluster
Department of Water Affairs and Forestry
Private Bag X 16
Sanlamof
7532

DEPT. VAN WATERWESE EN BOSBOU
1 - MAR 2007
DEPT. OF WATER AFFAIRS AND FORESTRY

Attention: Ms A Belcher **Your Ref:** 26/8/3/3 G30

PRELIMINARY DETERMINATION OF THE RESERVE FOR GROUNDWATER COMPONENT IN QUATERNARY CATCHMENTS G30B, G30C, G30D, G30E, G30F and G30G.

This Reserve determination was undertaken in anticipation of the contemplated compulsory licensing in the northern Sandveld area of the Western Cape Province, precipitated by a number of factors that included the following:

- Low rainfall the area receives,
- Significant groundwater abstraction for both municipal and agricultural purposes,
- The presence of sensitive and important ecosystems showing varying degrees of impact.

As a consequence, find enclosed herewith a copy of the Reserve determination, as approved by the Director-General, in support of the following water uses:

- Section 21(a) – taking water from a water resource;
- Section 21(b) – storing water.

Text Box 8. Sandveld Preliminary Reserve Determination

The lack of local attention cannot be blamed on local institutions or on local indifference. An early WUA set of minutes shows the WUA addressing a wide range of issues (Text Box 9) and not just the direct concerns of the commercial farmers.

Meeting Thursday 22 October 2009

3:00 pm afternoon

Venue: Raadsaal, Cederberg Munisipaliteit Lambertsbaai

1. Welcome
2. Apologies
3. Confirmation and Welcome of New Management of the Association
4. Sandveld SEBAL Project
   * Launch of 'Water Watch', 19 October 2009
5. Sustainable & Equitable Water Allocations in the Sandveld
6. Temporary use of Aquifers and Long Term Solution for Lamberts Bay's Water
7. School Gardens Project
8. Emerging Farmer's Forum
   * Borehole Monitoring Equipment of WUA
9. Municipal Matters
10. Other

Text Box 9. Example Northern Sandveld WUA meeting agenda

The voluntary adoption of the Greater Cedarberg Biodiversity Corridor provides evidence that there is a desire at a local level to take responsibility for the environment. In this case, commercial farmers have voluntarily agreed to leave specified parts of the farms uncultivated so as to permit the free movement of wildlife. Farmers have also sought (voluntarily) to adopt potato farming best practices in an attempt to minimise the environmental damage caused by potato farming. In another example, farmers have offered 'gratis' mentoring for emerging farmers. If farmers do over-exploit groundwater in the area, it is more likely as a result of a lack of information rather than irresponsibility. General goodwill does exist. Unfortunately, the information is generally unavailable to them because it is held in state departments and academic institutions.

This suggests that the most reasonable 'next step' would for hydrogeologists from state and academic institutions to be co-opted as members of the WUA. This would provide a two-way exchange of data, knowledge and concerns.

INTERVENTION 16: [Northern Sandveld] Hydrogeologists co-opted to WUA.

INTERVENTION 17: [Northern Sandveld] DWA information and monitoring data shared with WUA.

5.6.6 HERMANUS MONITORING COMMITTEE*

[*Note: At the time of writing this report, Overstrand Municipality was planning to combine the functions of two Monitoring Committees (the Onrus Monitoring Committee and the Hemel en Aarde Monitoring Committee) into one Monitoring Committee that would be called the Hermanus Monitoring Committee. For the sake of simplicity the generic term 'Hermanus Monitoring Committee' will be used from now on, even though it may be referring to the combined Monitoring Committee, or one or both of the Onrus and Hemel en Aarde Monitoring Committees.]

The regional location of Hermanus is shown in Figure 15.

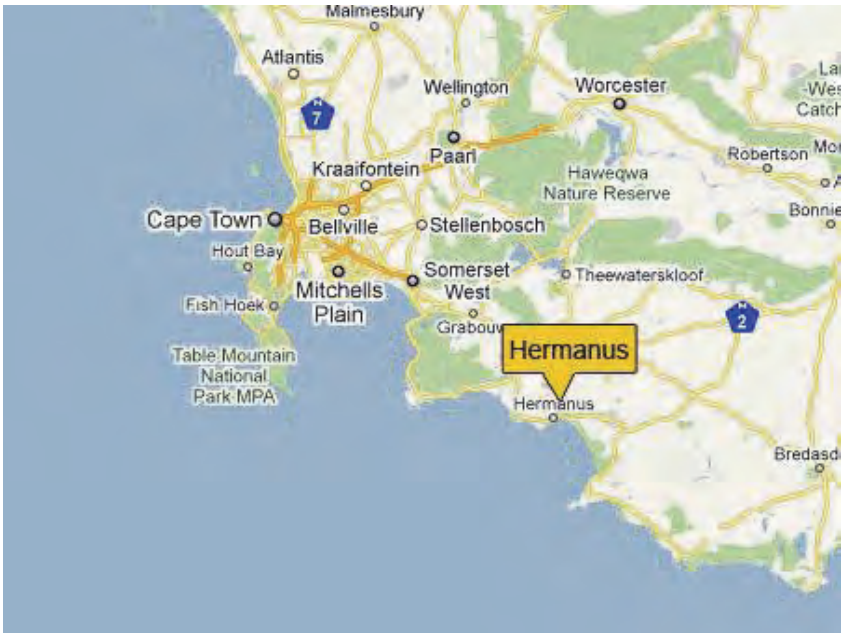


Figure 15. Regional location of Hermanus

Hermanus has obtained water from the De Bos dam since 1976. The annual allocation to the municipality from the De Bos dam is 2.8 million m^3/a whilst the average use by the municipality for the period 2003-2008 was recorded as 3.73 million m^3/a. In an attempt to meet this shortfall the Overstrand Municipality has introduced demand management to permanently reduce water consumption, and has commissioned investigations for alternative sources of water supply. These investigations lead to the identification, delineation and commissioning of groundwater from the Gateway, Volmoed and Camphill well-fields (Fig. 16), as a more cost effective method of obtaining additional water.

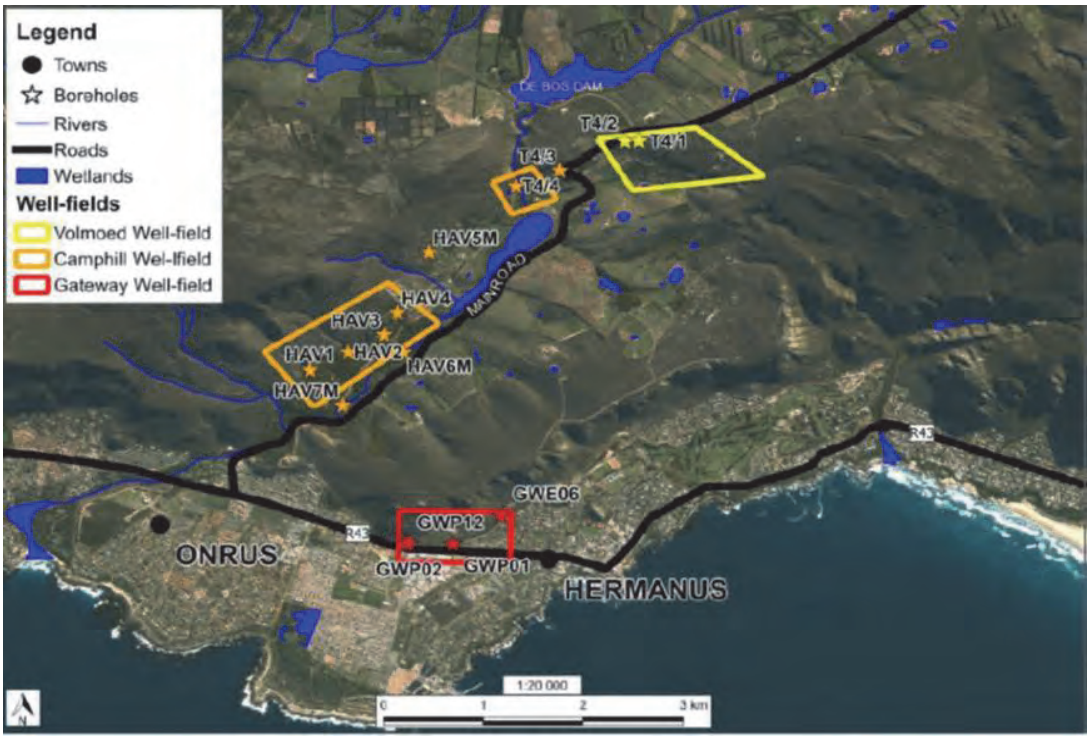


Figure 16. Gateway, Volmoed and Camphill Well fields, Hermanus

The three well-fields obtain groundwater from fractures in quartzitic rocks of the Table Mountain Group. Umvoto Africa, on behalf of the Overstrand Municipality, currently monitors the well-field and surrounding area. A license application was submitted in 2005 for the Gateway field and was granted in 2011. The Gateway licensing conditions stipulate that the maximum abstraction rate from the well field is 60 l/s and the maximum annual abstraction volume is 1,6 million m^3/years. Water use licenses for the Camphill and Volmoed well fields have also been granted. A combined maximum volume of 0,6 million m^3/years is currently licensed for these two well-fields.

The Gateway well-field monitoring has thus far been overseen by the Onrus Monitoring Committee, while the Camphill and Volmoed well-field monitoring has been overseen by the Hemel en Aarde Monitoring Committee. Since both Monitoring Committees have similar functions it is planned to combine them into one Monitoring Committee (the Hermanus Monitoring Committee) (Blignaut, 2014). The Monitoring Committees meet every 6 months. According to the Blignaut (2014)

no one is excluded from attending the monitoring meetings. Text Box 10 shows the persons attending the meeting on 4th June 2014.

NAME	AFFILIATION	POSITION
Jeanne Gouws	Cape Nature	Conservation Scientist
Hanre Blignaut	Overstrand Municipality	Deputy Director
Patrick van Coller	BOCMA	Water Use Specialist
Vuyani Tumana	DWA	Manager
Mike Smart	DWA	Deputy Director
Kornelius Riemann	Umvoto Africa	Principal Hydrogeologist
Sbongiseni Mazibuko	Umvoto Africa	Intern Hydrologist
Dylan Blake	Umvoto Africa	Senior Geologist
Giorgio Lombardi	Vogelgat Private Nature Reserve	Manager
Paul Lee	Umvoto Africa	Environmental Scientist
Tierck Hoekstra	Cape Nature	Area Manager
Peter Burger	Overstrand Municipality	Operations Manager
Stephen Muller	Overstrand Municipality	Director Infrastructure and Planning
Bernhard Turkstra	Onrus Water Users Association	WUA Chairman
Jamie Hart	Hermanus Ratepayers Association	Water and Infrastructure
Patrick Robinson	Overstrand Municipality	Infrastructure and Planning Management

Text Box 10. Monitoring Committee Participants, Onrus, 4th June 2014

Since the Gateway well-field is essentially part of the Hermanus urban area, it is perhaps not surprising that no representatives from the agricultural sector attended the meeting. In the case of the Volmoed and Camphill well-fields there has also been little interest from the agricultural sector in the activities of the Monitoring Committee. This is surprising since these well-fields are located adjacent to significant farming activity. According to Blignaut (2014) lack of interest from the farming community (Text Box 11) could be ascribed to two issues, (1) farmers perceive no impact or threat of impact from the municipal well-fields and, (2) the farmers have little interest in the theoretical issues discussed at the meetings.

'Discussion regarding the poor interest of local farmers and other water users on water issues ensued. KB suggested another visit to the farmers and mentioned that more monitoring boreholes are needed from private users on the Hemel en Aarde Valley. PL suggested initiating a statement to the farmers every 6 months after the monitoring reports/meeting and BT suggested a summary of monitoring with interpretation attached when inviting farmers to the next monitoring meeting.'

Text Box 11. Extract from minutes of Hemel and Aarde Monitoring Committee

Besides monitoring, Umvoto Africa also provides well-field management advice to the Overstrand Municipality. The monitoring makes use of sophisticated equipment and is highly meticulous (Mathews, 2013). For example, data are communicated in near-real-time using telemetry. Most of the boreholes are monitored automatically at 30-minute intervals. If the electrical conductivity of groundwater from the Gateway well-field starts to rise and reaches 150 mS/m, then the pumps will switch off automatically to eliminate any possibility of saline intrusion, and water treatment staff will automatically be alerted of changes by SMS. For these reasons, monitoring and management of these well-fields can be described as highly professional and technical.

Well-field management is, however, only one part of governance. The high levels of competency in the monitoring and management of the well-fields at Hermanus should not be confused with good governance. Governance is as much about human relations and human negotiations. There is no direct correlation between the use of high-level technology and expert input, and good governance. It is suggested that the role of the Hermanus Monitoring Committee is essentially defensive. Their aim is to defend against over-abstraction causing depletion of the groundwater resources; to defend against municipal abstraction causing ecological impacts; and to defend against municipal abstraction causing impacts to other groundwater and surface water users. In addition, their role is to defend against incorrect perceptions that municipal abstraction has caused impacts when it has not. A sophisticated monitoring programme and the input of Monitoring Committees are ideal for these purposes.

However, should the municipality be the recipient of third-party impacts, rather than an accused protagonist, the whole system would be less than ideal. It would be difficult to determine the cause of third-party effects since landowners outside the well-fields seem reluctant to participate in the monitoring. And while it is a relatively simple matter for the Municipality to reduce abstraction should its abstraction be causing unacceptable impacts, it will not be so simple to persuade third parties to mitigate unacceptable use even if it can be proven. The Monitoring Committee(s) have no authority, either statutory or tacit to enforce reductions from third parties. Should such a problem arise, it would presumably have to be delegated upwards to the Onrus River Water User Association. In turn, this association would have to delegate the issue upwards to the CMA.

For good local groundwater governance to occur these sorts of issues must be resolvable at the local level. While a Monitoring Committee might not have the explicit authority to resolve these issues, it might have more tacit authority and have more powers of influence if it monitored, and had jurisdiction over, all the users in a given groundwater system.

In terms of the ODP, it is suggested that the problem demonstrated here is one of boundaries. Neither the user boundaries nor the resource boundaries are clearly defined. Virtually anyone may attend a Monitoring Committee meeting so it is clear than user boundaries are diffuse – or rather interested and affected parties that may be deemed 'users' or 'users representatives' in a very broad sense – are very diffuse. The resource boundaries are also diffuse. The resource extends further than the well-fields, but to what extent remains unclear? The resource boundary should be delineated and users within this boundary should interact as a coherent governance body. This would ensure that all users get their fair share of the resource and use the resource within the parameters of relevant regulations. Presumably the Onrus River Water User Association should provide this function, but this is not currently the case. Blignaut (2014) observes that the Onrus River WUA has received little interest since its inception. This may be because it is perceived to be 'toothless,' and is currently ‘dormant’ while it awaits the completion of a verification and validation of existing use by the CMA. This process could take a minimum of two to three years. Therefore, it is suggested that extending the responsibilities of the Hermanus groundwater Monitoring Committee the entire area of the WUA rather than just the

municipal well fields, could have scope and value. This lead to the suggested intervention:

INTERVENTION 18: [Hermanus Monitoring Committees] Expand the role of Monitoring Committees so that they monitor ALL groundwater use in a coherent groundwater domain, rather than just one user in an incoherent domain.

5.7 Where local governance is not needed

It might seem perverse to try to advocate the improvement of groundwater governance by suggesting an intervention that would require *less* input from DWA and other institutions! However, the reason for this is that much of South Africa is underlain by aquifers that are local and/or discontinuous and/or low-yielding. Thus many of these aquifers either do not constitute CPRs, or are common pool, but are so low-yielding, that there is no benefit in treating them as CPRs. In these cases it is highly likely that the only party affected by the taking of groundwater, would be the lone user. Their borehole would dry up before any third party impacts were generated.

In these cases, groundwater does not constitute a CPR and thus the ODP cannot be applied.

It is also suggested that not only is common pool governance not applicable in these cases, but any form of attempted governance is also not applicable. Applying, for example, licensing, reserve determinations or general authorisation, is of dubious value. Admittedly the groundwater being abstracted beneath a private property is a public good, but access to the public good is via private investment (e.g. a borehole) The question can be posed: why should public resources be used in an attempt to prevent a private citizen suffering the negative consequences of their own private investment decisions. An additional supporting argument is that none of the existing controls appear to have worked anyway. In these situations it is suggested that it would be far better to treat the groundwater as de facto private water. Or the user could be given general authorization to abstract any quantity of water – provided it is within the capacity of the resource.

This proposed policy echoes the White Paper (DWA, 1997) on National Water Policy. The policy document is of the opinion that groundwater should only be managed where there is a strong and compelling need to do so.

Gisser and Sanchez (1980) have repudiated the pervasive and intuitive belief that public intervention automatically leads to social welfare gains with regard to groundwater. Their so-called 'Gisser-Sanchez effect' (Koundouri, 2004) showed no welfare gains between totally unregulated aquifers, and aquifers managed by institutions. There have been many attempts to refute this effect, especially since it is only based on a single-cell ('bathtub') model of groundwater (Katic and Grafton 2012), and because it ignores environmental effects (Esteban and Albiac, 2012). However, it has been shown (Brozowic et al., 2010) that for small aquifers the Gisser-Sanchez effect still applies reasonably well. [Brozowic et al. define 'small' as aquifers of a few hundred square kilometres or less.] Since small aquifers are the norm in South Africa it may be prudent for policy makers to take the Gisser-Sanchez effect

into consideration. This would imply (a) excluding the large parts of the country where aquifers are [very] small and low-yielding from groundwater regulations, and (b) doing cost-benefit studies before embarking on regulations [or local-scale governance capacity building] in the remainder of the country.

INTERVENTION 19: Cost-benefit studies to identify where regulation of groundwater use is justified, and where regulation is not justified.

Thus, while it is accepted that DWA is the guardian/trustee/custodian/manager of the nation's groundwater resources, it is disputed whether DWA can or must take a hands-on and direct management approach to *all* groundwater in South Africa. DWA's role in groundwater management should be more about *ensuring* good groundwater management, and less about *doing* (or trying to do) groundwater management itself. It may be the *ultimate manager of last resort* but it is suggested that the attempted public intervention in insignificant aquifers is bad management. Management in this form constitutes a waste of public resources and achieves very little, if anything. These public resources could be put to better use elsewhere.

An indication of the areas where common pool governance is not appropriate, and any intervention may be unjustified can be gauged from a borehole yield map of South Africa (Fig. 17).

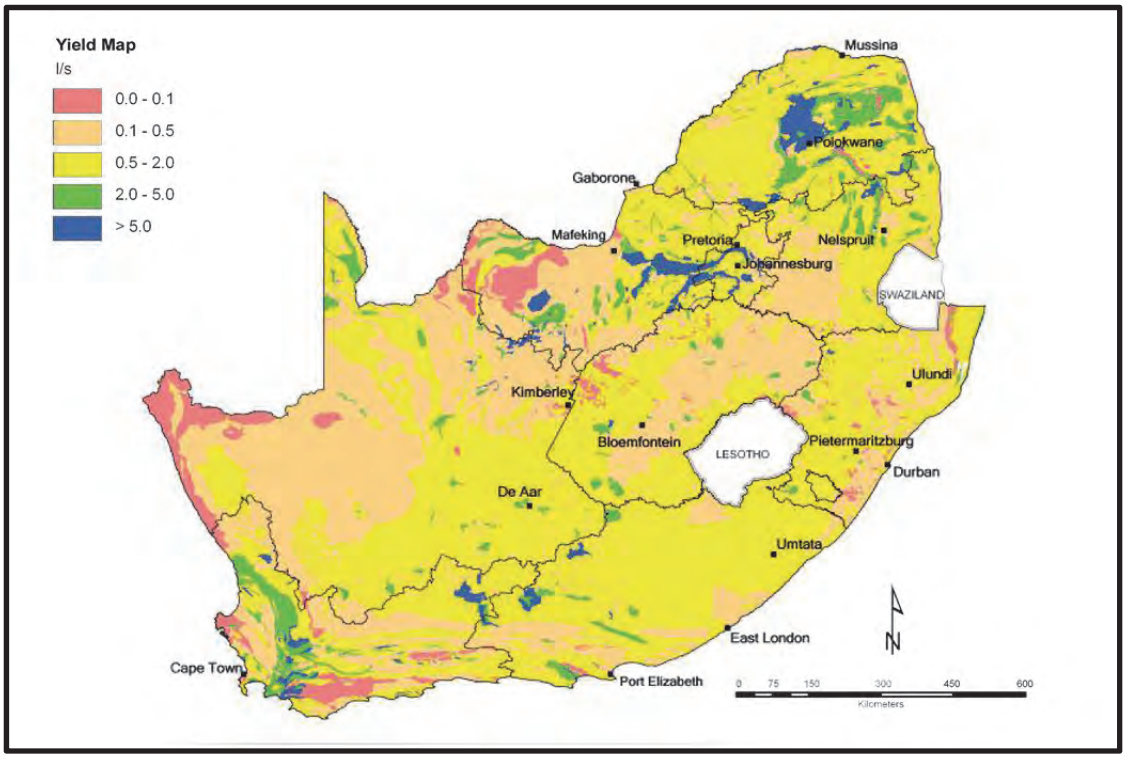


Figure 17. Borehole Yield Map of South Africa (DWA, 2010)

The yield map is based on which of the above 5 yield categories the median yield for a given area falls. Although one would need more local-scale detail to make definitive decisions, it is argued that this map gives an indication of the percentage of the area of South Africa that does not justify high-powered groundwater intervention. In the yield ranges 0,0-0,5 the yields are so low that interventions

cannot be justified. The 0,5-2,0 l/s might be regarded as marginal – some intervention based on the specifics of local hydrogeology, while a median yield range of greater than 2,0 l/s will mostly point to the need for management and governance interventions.

5.8 'Hot Spots'

The previous section has advocated not attempting to improve groundwater governance in certain areas. In the remaining area (the high priority area), active interventions may not be needed everywhere either. 'Hot Spots' need to be identified. Scientists, water managers and other stakeholders are usually well aware that certain areas require special attention. Reasons for special concern in 'Hot Spots' might include; over-utilization and unsustainable use of an aquifer, conflicts between users, damage to the environment caused by intensive use and so forth. 'Hot Spots' are usually easily identified. The appropriate Ostrom Design Principle/s should be identified and applied to tackle the governance issues in the 'Hot Spots'.

INTERVENTION 20: Tackle groundwater governance 'Hot Spots' by supporting the implementation of whichever missing Ostrom Design Principle seems the most feasible and most beneficial to implement.

There can be no specific guidelines for this. Local circumstances and local perceptions will dictate what issue is tackled first. There needs to be 'interest' or 'motivation' to drive the process of improving good local groundwater governance.

6 IDENTIFYING THE KEY INTERVENTIONS

6.1 Introduction

Chapter 5 has identified numerous, possible interventions. Some interventions are general, while some are relatively specific. Some interventions have been subject to prioritising, while some have not. Because of the large number of interventions identified it was decided to attempt to group them into 'umbrella' interventions, and then prioritise the 'umbrella' interventions, rather than simply attempt to prioritise all the interventions.

6.2 Summary of interventions

A recap of the interventions identified, followed by the source page numbers:

INTERVENTION 15: [Philippi] Hydrogeologists from academic and state institutions to motivate benefits of PHA doing their own monitoring and to provide support where necessary. 101

INTERVENTION 16: [Northern Sandveld] Hydrogeologists co-opted to WUA. 105

INTERVENTION 17: [Northern Sandveld] DWA information and monitoring data shared with WUA. 105

INTERVENTION 18: [Hermanus Monitoring Committees] Expand the role of Monitoring Committees so that they monitor ALL groundwater use in a coherent groundwater domain, rather than just one user in an incoherent domain. 109

INTERVENTION 19: Cost-benefit studies to identify where regulation of groundwater use is justified, and where regulation is not justified. 110

INTERVENTION 20: Tackle groundwater governance 'Hot Spots' by supporting the implementation of whichever missing Ostrom Design Principle seems the most feasible and most beneficial to implement. 111

6.3 Grouping and Prioritising the Key interventions

The results of the grouping and prioritising (Table 10) are followed by an explanation of the rationale for the grouping and sorting.

Table 10. The Key Interventions

KEY (=UMBRELLA) INTERVENTION	Component Interventions	Responsibility
Tackle groundwater governance 'hot spots' by supporting the implementation of whichever missing Ostrom Design Principle seems the most feasible to implement by external institutions and most beneficial to local stakeholders (existing intervention 20)	14-18	DWA and/or WRC and/or Tertiary Education Institutions and/or National Groundwater Governance Association
Look for ways to improve social capital in local groundwater governance. (*new* intervention)	all	National Groundwater Governance Association
Create a national groundwater governance association to share ideas and act as a catalyst for change (*new* intervention)	all	'Charismatic' and/or motivated individual
Include a commitment to the Ostrom Design Principles in the GWS. (exisiting intervention 10)	1-9, 11-13	DWA groundwater components

Since the purpose of this study is to identify key interventions to improve groundwater governance at the local level, the priority interventions are those that actually engage at the local level**.** Changes to the strategies of external institutions, to scientific methodologies, to water law, can all play a supporting role but cannot, by themselves, act as a catalyst for good groundwater governance at the local level. This study, therefore, contends that a local-level, umbrella intervention is the highest priority intervention needed. This umbrella intervention represents the optimum combination of (a) facilitation of the implementation of a missing Ostrom Design Principle, (b) ensuring that the concerns of one or more stakeholders are addressed and, (c) ensuring that the intervention is within the resource capability of the external institution providing the support.

This key intervention leads to different interventions in each of the three case study areas. However, all these proposed specific local interventions have one thing in common – they are all aimed at improving the *social capital* of the local groundwater governance process. These interventions aim to increase *trust* in the governance process and they aim to increase 'motivation' in the governance process. For example, trust might be increased because local stakeholders believe there is a legitimate local decision-making process that addresses their needs, because they see external organisations as being sympathetic to their needs, and because higher-level institutions see lower-level institutions as being competent and therefore appropriate recipients of delegated authority.

It has been identified that ODP are essentially tools to increase social capital (López-Gunn 2012). Therefore, the second key intervention is proposed so that it can operate in parallel to the ODP. As a result, the key intervention can support and reinforce the design principles and allow for ways to build social capital that might not have been included in the design principles.

Since social capital has been proposed to be a key intervention, and has received little specific attention in this report thus far, the issue of social capital and its relevance to groundwater governance will be explored in more detail in chapter 5.

None of the interventions placed any great requirement for laws to be changed, institutional strategies to be changed, or for funding to be raised. For example, some (or all) of the proposed interventions could be placed under various parts of the Groundwater Strategy, chapter 5: Sustainable Groundwater Management. Text Box 12 contains two actions from the Groundwater Strategy that seem relevant:

- Establish a Groundwater Resource Governance Section in the Department.
- Support the water services institutions, in order to take up operation and management functions, and ensure the sustainable utilisation of the resource. Community involvement and awareness can help alleviate theft and vandalism.

Text Box 12. Excerpt from Groundwater Strategy re governance (DWA, 2010)

Many local interventions could be made without depending on DWA. Therefore, action could be taken without the need to wait for or expect the DWA to take the

initiative. Thus there is no need to pass the buck to DWA and sit back and wait for it to do something. Social entrepreneurs, tertiary educations or the WRC could facilitate many of the interventions. This poses the question; what organization is the best 'agent of change' to improve local groundwater governance? The position taken by this paper is that although many institutions could play an important role in improving local groundwater governance, there is no institution that is obviously the best institution, particularly because few have any corporate obligation to be involved.

The best 'agent of change' would be a committee, or association of user associations or foundation or think tank (or any other body not yet thought of and presented here), that acts as an umbrella group for local groundwater governance. The ‘agent of change’ could facilitate the sharing of ideas and expertise, facilitate the initiation of ongoing 'pilot projects', test schemes and/or groundwater governance research centres. This proposal is the basis of the third key intervention: 'Create a groundwater governance association to share ideas and act as a catalyst for change.' Such an association could be an external, non-DWA initiative with DWA invited to participate.

And finally, the 4th key intervention is: Include a commitment to the ODP in the GWS. The 'support' type of interventions can be placed under this intervention. While this key intervention is also very important, it should be noted that it is primarily about support and not implementation. As noted earlier, it would be unwise to focus on support at the expense of implementation.

7 A PERSPECTIVE FROM PUBLIC PARTICIPATION, SOCIAL CAPITAL AND SOCIAL LEARNING

7.1 Purpose of this perspective

One of the key interventions recommended by this project was to look for ways to improve social capital. All the other key interventions also contain and element of 'something intangible'. 'Something intangible' refers to what is inadequately, but probably best simplifies to *relationships*. Relationships, as they relate to each key intervention, are critical to finding solutions to governance problems. Relationships are difficult to 'pin down'. They are not concrete in the way that e.g. quantitative data is. They cannot be precisely pinned down in the world of science, the law or institutions. Although science, the law and institutions are important, the intangible issue of relationships needs to find a legitimate 'place' in considerations for good governance. *People* have conflicts, *people* are users of groundwater, *people* feel they have the democratic right to have a 'say' in their world, and *people* expect services from government institutions. Without solving this problem, laws, science and institutions can only have a limited effect on and provide a limited solution to good groundwater governance. Relationships are studied in the social sciences and fall under concepts such as *social capital*, *social learning, and public participation*. For this reason, these concepts are briefly introduced and reviewed to establish whether or not they are relevant to this investigation.

7.2 Background

It is increasingly recognised that harnessing communities to either autonomously manage or co-manage environmental systems, is a critical component of successful governance and sustainable use of resources. Mallants (2013) argues that ***"based on empirical evidence, participation of local neighbourhood organisations and collective management can be effective approaches to good water governance."***

Pahl-Wostl et al. (2007) describe recent changes in water resources management as a ***"major paradigm shift".*** Technical solutions to social-ecological problems are no longer adequate and ***"participatory management and stakeholder involvement are becoming increasingly important".***

Rydin and Pennington (2000) argue that there are two 'rationalisations' for public participation. The first is that individuals and communities have a democratic right to participate in the 'public policy process' and the second is that public participation can improve the policy process (the policy process can better reflect community values, reduce conflict and/or 'tap into' community knowledge).

Concepts such as public participation, social capital and social learning, like many academic concepts, are complex areas of study in their own right. The definitions and meanings put forward here are intended to introduce the debate, not be the last word on it. In many ways the meanings overlap, further adding confusion to discussions about these social phenomena. Rather than exploring these semantic complexities, the purpose of this section is to provide a basic understanding of the concepts, to provide a basic demonstration of the potential (positive) application of

these social phenomena in groundwater governance, and a basic understanding of the possible challenges related to the concepts.

7.3 Social Capital

The term 'social capital' is known to have been in use as early as 1916 (Keeley, 2007) when it was defined as ***"those tangible assets [that] count for most in the daily lives of people: namely goodwill, fellowship, sympathy, and social intercourse among the individuals and families who make up a social unit"***(Hanifan, 1916). Since then the concept have gradually come into more widespread use.

In the 1990s researchers from environmental and related sciences began to borrow and apply the idea of social capital, albeit with the inevitable evolution of its definition and meaning, to social-ecological issues. By applying these concepts, researchers were able to question, explain and provide answers to perceived weak governance of social-ecological systems and to examine the effectiveness of bottom-up strategies for improved governance, resource protection and sustainable resource use. A more recent definition put forward by Sano (2008) in a study on common-pool resource management suggests that:

"Social capital…[can be] defined as a set of values, such as the norms of reciprocity, and social relations embedded in the social structure of a society, that enable people to act collectively to achieve their desired goals."

Pretty (2003) argues that in contrast to top-down regulation, the option of local groups managing common resources,

"…has been shaped by [recent] theoretical developments in the governance of the commons and in thinking on social capital. These groups are indicating that, given good knowledge about local resources; appropriate institutional, social and economic conditions; and processes that encourage careful deliberation, communities can work together collectively to use natural resources over the long term."

Social capital can be seen as the non-monetary wealth of a community although it may provide the connections necessary for access to financial and other resources. Social capital does not exist everywhere in equal 'amounts'. In some places it may be weak and in others strong. It may also be fluid, changing over time between states of weakness and strength. Where it does exist e.g. a group of co-operative and trusting neighbours or a close-knit group of farmers or individuals who share a groundwater resource for drinking water, there is an opportunity for policy makers and decision makers to direct the existing capital or to build on existing capital to promote their governance agenda.

The literature describes three types of social capital: *bonding*, *bridging and linking capital* (Sano, 2008; López-Gunn, 2012). Bonding social capital can be explained as the ties between groups or individuals from fairly homogenous groups whereas bridging social capital would be the ties that exist between diverse groups and individuals. Linking social capital describes hierarchical linkages between groups with authority e.g. institutions, NGOs and local groups. These concepts illustrate that the networks and bonds between individuals and groups can be complex. In social-ecological governance issues, these are important distinctions because different

types social capital may be useful at different scales e.g. solving a problem between two villages or harnessing the social capital of large communities across borders (together with NGOs and government institutions) to manage a shared aquifer.

Case study on social capital and groundwater in Spain (López-Gunn, 2012)

López-Gunn (2012) conducted this study across two regions and aquifers in central Spain – Western and Eastern Mancha. The two areas, although similar in some ways, also have significant differences (population size, number of Water User Associations, how water user groups emerged, institutional arrangements, legitimacy and participation). The Eastern Mancha has a large population of around 2.5 million people, while the Western Mancha only has about 270 000 people. Both areas have one central Water User Association. However, the management arrangements – social/institutional for water differ. While the Western Mancha WUA has 17 000 farmers (it also has 20 lower level WUAs – farmers are members of their respective local WUA and also belong to the central WUA), the Eastern Mancha only has 659 users.

Western Mancha

The creation of the Western Mancha WUA happened in response to the recognised over-use of the aquifer in 1987. Leader rivalry in Western Mancha led to a split into two rival organisations. Because the Western Mancha WUA took 5 years to form (only established in 1996), the 20 local WUAs developed almost immediately after 1991 in a bottom-up effort. The slow establishment of the central WUA can be directly attributed to the aforementioned rivalries. López-Gunn contends that farming elites ('farmer unions, large landowners, charismatic individuals active in local politics') dominated and it was difficult for those less powerful to challenge the 'status quo'. The less powerful were often 'captured' by the powerful to further their cause. The 'mandate' of the WUAs also changed. Instead of 'being [water management bodies] formally part of river basin administration' they were 'captured by farming unions, becoming lobbying organisations, seeking subsidies'. Some WUA presidents would act as farmer union representatives simultaneously, there was interference in WUA elections, and often WUA and farmers' unions shared offices and billing. López-Gunn argues that because the central WUA was not established from the bottom up, it did not '[gather] internal legitimacy and was 'unable to mobilize the strong internal 'stock' of bonding social capital into a 'flow' of collective action between villages.

Eastern Mancha

The formation of the Eastern Mancha central WUA emerged after a prolonged drought. The crisis led to 'major public demonstrations'. Farmers united (within 3 years of its formation, 85% of farmers had joined the central WUA) to 'introduce water restrictions and closure to new users'. Further legitimacy was given to the WUA when it was declared the only 'officially recognised WUA' by the Jucar Water Authority (this increased membership to 95% of farmers). Despite initial 'feeling[s] of tension and distrust, over time and with the 'exercise of leadership' farmers began to '[buy] into the idea. The author argues that the Eastern Mancha learned from the organisational model failures and conflict in the Western Mancha. The farmers realised that 'collective action to defend their interests to secure access to water' was of 'key importance'.

Text Box 13. Case study on social capital and groundwater in Spain (López-Gunn, 2012)

7.4 Social learning

Reed et al. (2010) suggest that, ***"social learning is increasingly becoming a normative goal in natural resource management"***. The authors do not provide a concise definition of the term but argue that two criteria must be present for learning to be regarded as 'social learning':

1) Individuals involved in the process must have demonstrated that, at the very least, new information can be recalled. At a more substantial level of learning, individuals should have undergone 'changes in attitude, worldviews or epistemological beliefs'.
2) Learning should be expanded to the wider community through face-to-face communication, social media, the Internet etc.

In the context of socio-ecological issues social learning can play a significant role in groups and individuals:

- Learning from experience, acquiring new knowledge, learning more by 'understanding and re-interpreting' information through communication, undergoing changes in attitude, questioning assumptions and learning about the consequences of their actions. In a socio-ecological context, an example would be that a community might pollute their groundwater source assuming that the groundwater source will always be available to supply water. However, they learn that there are consequences to their actions and learn to change their behaviour with regard to groundwater.
- Learning in organisations and communities can lead to improved collective management of social ecological systems. The change in thinking at this larger scale level should be reflected in changes to the practices of 'wider social units'. These wider social units may be drawn from various 'communities of practice'. An example from groundwater would be that e.g. a government groundwater department (scientific knowledge) in collaboration with local communities (local knowledge) collectively change their management strategies because of a new and shared understanding of and issue such as climate change.
- Learning spread through social media or mass media can change opinions and views. People can be persuaded to change their thinking from a small scale (one on one) right up to a macro scale (television, the internet). An example would be e.g. civil servants from a government groundwater department taking an educational road show on groundwater to rural communities. Community members who attended the road show then share their knowledge with those who did not attend.

Case study of social learning in Morocco (Faysse et al., 2013)

This 'action research project' emerged from a 'groundwater and agricultural crisis' in the Chaouia coastal region of Morocco. The project was established to develop a 'dialogue between local stakeholders in a situation of weak governance of the social-ecological system'.

The Chaouia area was used for large-scale crop production in the 1960s and experienced an agricultural 'golden age' (and was known as the Moroccan California) in the 1980s. But overexploitation leading to falling groundwater levels and seawater intrusion has led to a 'weakening' of the agricultural sector. Despite this weakening, agriculture remains the main employer. Apart from the large-scale extraction of groundwater for irrigation, a few boreholes are located in rural communities for drinking water.

The groundwater crisis led to social changes – some farmers moved away, some gave up farming and became farm hands on other farms while yet others changed the types of crops or changed to cattle rearing. Interviews conducted during this period revealed that farmers did not have a clear vision for the future and they did not believe that collective or individual action could be taken to 'ensure sustainable agricultural activity in the region for the future'. With virtually no consultation, the government stepped in to develop strategies to solve the problem but their suggested projects, despite not being implemented, did not allow for 'discussion of possible alternatives'. The author contends that the relationship between government and farmers remained unconstructive (e.g. farmers believed that attending meetings was a waste of time and government officials believed that farmers preferred to complain and not develop viable proposals).

Governance and collective action in the area can be described as weak. The multi-stakeholder dialogue sought to analyse and find strategies to solve the on-going crisis. A carefully selected team of government officials were invited to meet with farmers from the same village (rather than wide-ranging meetings). Despite initial problems of trust, attendees were encouraged to find desired future scenarios together. At the end of the workshops, the overall response was positive but farmers felt, understandably, that unless the workshops led to outcomes, the process had been futile. The workshops did not lead to long-term solutions but weaknesses in the dialogue process were identified and could be used to inform future attempts to create a dialogue. The authors argue that the dialogue process 'paved the way for social learning'.

Text Box 14. Case study of social learning in Morocco (Faysse et al., 2014)

7.5 Public Participation

Unlike social capital and social learning, the term 'public participation' is already in widespread use and those working in the field of environmental management are, more than likely, familiar with its alleged advantages. Mallants (2013) contends that, ***"public participation in no longer a theoretical concept but has proven its merits in some of the more contentious and complex projects in Western democracies – water management projects not excluded"***. André et al. (2006) define public participation as:

"…the involvement of individuals and groups that are positively or negatively affected by a proposed intervention (e.g., a project, a program, a plan, a policy) subject to a decision-making process or are interested in it".

Du Plessis (2008) argues that an increased awareness of peoples' rights in general, and peoples' environmental rights in particular, has led to the idea that public

participation is a critical prerequisite for participatory democracy. He suggests that the 'law' increasingly recognises that those who are governed should 'engage in their own governance'. He describes the expansion of public participation over the last 40 years as a 'participation explosion'. Since environmental and development issues directly affect communities and individuals, it stands to reason that they should have a 'say' in how the issues are managed and how policies are developed. However, it is important to note, that the willingness on the part of governments/institutions to foster participation or the participation process itself, are not without problems and challenges.

Levels of participation vary from situation to situation and at different stages of a process (André et al., 2006). The first is 'passive participation or information reception', the second 'participation through consultation', and the third 'interactive participation'. Mostert (2003) describes the use of public participation in governance as a 'different mode of governance' and is not merely a 'technique'. Many factors need to be considered when the public are involved in a process e.g. who should be included, the roles and rules of participation, managers of the process, the scope of the issues, the timing of participation, policy research, and methods of public participation.

Public participation in Kenya – Water Resource User Associations in the Upper Ewaso Ngiro River Basin (Rutten and Aarts, 2013)

This African Study Information Sheet examined the effectiveness of the Water Resource User Association (WRUA) in the Upper Ngiro River Basin (an area of 15 200 km^2). The Study used household interviews to gather qualitative data on public participation through the WRUA in the area. The 2002 Kenyan Water Act recognises that local communities are pivotal to sound water management. WRUAs have been established around the country. Membership is voluntary and will therefore, the Info Sheet claims, 'attract committed members'. The objectives of the WRUAs are to intervene and resolve conflicts, promote compliance with regulations, promote sustainability, and promote fair access to water. These objectives are to be realised through e.g. social learning (exchanging ideas or discussing projects), ensuring that all members' views and consent are taken into consideration, intervening in conflicts, lobbying for resources, and taking an active technical role in monitoring and management of water resources.

Recent changes (population increase, land use changes, stress on water resources, climate change) have increased the likelihood of conflict. Local households interviewed for the Info sheet identified 'high demand for river water to a rise in agricultural activities' as the 'greatest problem in the area'.

WRUAs were established in the area between 1998 and 2010. The increasing number of conflicts during that time 'triggered' the establishment of the associations. A management committee of fifteen members represent water users across the WRUA area. Members are elected to the key positions of treasurer, chairman, and secretary.

People interviewed for the Info Sheet viewed the WRUA in a positive light and believe that it 'manages and controls their water resources well, which generally leads to more water being made available'. People also felt that meetings to 'raise awareness' had promoted 'increased cooperation'. Positive feedback about the effectiveness of WRUAs was obtained from the national Water Resource Management Authority. They contend that WRUAs are promoting 'household water conservation projects' and 'efficient use of water'. NGO employees working in water provisioning have found that the work of the WRUAs have made their work easier. The social learning that has taken place amongst the communities has made it easier for them to explain why water-management measures are necessary.

The Info Sheet argues that fieldworks has established that there are three reasons for the success of the WRUAs:

1) The WRUAs are an 'easily accessible platform for discussion' when conflicts arise between users.
2) Since WRUAs' members are from the local community, they are able to facilitate discussions and conflict resolution.
3) The WRUAs have created a link between up-stream and down-stream water users thereby creating an 'interconnectedness' between communities. Practical steps have been taken to improve this interconnectedness – up-stream communities are now aware of their impacts on downstream communities and have water use and water storage strategies in place. Downstream users have been persuaded to use dialogue rather than 'violence' to solve problems.

However, it should be noted that despite the many positives that the WRUAs have brought to water management and users of the area, conflict remains an issue. The Info Sheet also cautions that WRUAs do not always have 'sufficient levels of professionalism' in either water management or conflict resolution, or sufficient financial resources, or implementing capacity. The Info Sheet recommends that two improvements are needed:

1) Training should be more extensive – increasing the length and depth of training and extending training to community members (not just WRUA members).
2) Community knowledge and experience needs to be combined with the knowledge and experience of a professional e.g. a full-time professional manager should be coupled with the WRUA.

Text Box 15. Public Participation in Kenya (Rutten and Aarts, 2013)

7.6 Discussion

The three concepts discussed above are interrelated and together they have a role to play in a more successful form of governance. The general rationale for including the stakeholders in governance is to improve the process and outcomes – for the benefit of people and the environment. In practice, utilising social capital, facilitating social learning and promoting public participation, are not without challenges. In order for these social phenomena to be utilized effectively, institutions have to have the political will to understand and drive the process in a meaningful way. Or there has to be an innate motivation within a community to drive the process on their own.

The pool of academic literature on social learning, public participation and social capital *in groundwater governance* is still limited. Unfortunately, the available studies sometimes lacked adequate 'depth' to – in a sense – promote social learning about social learning and the other concepts.

The case studies revealed that social capital, social learning and public participation 'play out' in different ways in different scenarios. In the Western Mancha, politics and 'power struggles' play a major part in limiting the effectiveness of public participation. In Kenya, public participation, learning and social capital are being utilised effectively and are making a positive difference to community based management of water. However, conflict between individuals and communities remains a challenge. The Moroccan example demonstrates that if the implementation of public participation strategies is flawed, very little is achieved. It appears that if a top-down strategy is to be successfully implemented, then the authorities must have a sound understanding of the local communities (political landscape, relationships). No location is exactly the same as the next and each authority (if they are actively involved) has to harness the strengths of the local people and minimize the weaknesses. Authorities then need to collaborate by sharing expertise and resources with local communities to build on local management strategies thereby creating creative, effective, and representative bodies.

If an umbrella term had to be selected to explain what is needed to make groundwater governance work, then the term could simply be *social capital*. It seems plausible to suggest that the presence or absence of social capital explains why cases of local governance work, while others do not. While it is 'satisfying' to be able to pin down explanations of good groundwater governance to one concept, it is important to note that this concept has a plethora of different meanings and different implementations. It offers little in the way of concrete advice on the 'how to' aspect of developing good groundwater governance.

However, if it is social capital that underpins good groundwater governance, then other things start to make more sense. For example it has been observed in several studies that it is far easier to get local groundwater governance operational if there is an existing local institution already in place (the institution may be water related or not). The social process explanation for this would be that there is already social capital in place, and it that it is easier to build on existing social capital than create social capital where none currently exists.

Social processes offer an alternative perspective on ‘successful’ groundwater governance (rather the compliance with rules perspective). Success can be measured according to an increase in social capital and the existence of sustainable and effective processes for dealing with water issues, rather than whether one arbitrary action has achieved a once-off, arbitrary ‘right’ result.

This 'organic' nature of this approach highlights that a ‘good governance machine’ can not be ‘built’, handed over to a community and immediately made effective. Social capital does not work in this way. Building social capital and improving local groundwater governance is an ongoing, long-term project.

Social capital, social learning, and public participation cannot be successfully imposed on a local governance system by an external institution that is itself flawed, (rigid, bureaucratic and/or autocratic). The external institution needs to be dynamic (undergoing social learning, actively building social capital and taking part in public participation). Ideally all institutions involved in governance should take social processes into consideration. They can’t simply be imposed on local resource stakeholders.

7.7 Concluding remarks regarding social phenomena

This cursory introduction to social phenomena suggests that the issues being grappled with in this project could also be placed under the broad umbrella of social phenomena. Paying attention to the social aspects of governance is certainly no panacea and does not guarantee success. Alternatively, not paying attention to social aspects does seem to predicate failure. Although social phenomena do not guarantee success, they are a prerequisite to good groundwater governance.

Terms like 'social capital' are difficult to pin down. Many attempt have been made to adequately define these concepts. Despite the ‘fuzziness’ of these definitions, these concepts play a useful role in guiding human endeavours. Groundwater governance ‘designers’ and ‘facilitators’ will need to take these concepts on board if they are to make a difference. Rules, the law and science are inadequate to address groundwater governance.

8 REFLECTIONS

8.1 Introduction

The 'picture' of groundwater governance (and attempts to improve groundwater governance) that has emerged from this study is of a process that is messy, ongoing, iterative, idiosyncratic, and that is fraught with pitfalls. Groundwater governance requires an ongoing commitment to get it 'up and running' and working long-term. There is no blueprint that can be designed, presented to a local groundwater user group, and then left for them to implement on their own. A ready-designed blueprint will not work for the following reasons, (a) no blueprint exists that will work everywhere, and (b) getting local groundwater governance to work (and to work better) is an ongoing process (not a once-off process). Therefore there is *no* blueprint or set of rules that can be simply imported into the South African groundwater governance context.

Every instance of good groundwater governance seems to be unique. It would appear that groundwater governance can occur with many different 'flavour combinations.' These 'flavours' can include, but are not restricted to:

- Abundant data – scarce data.
- Strong hydrogeological science input – weak hydrogeological science input.
- Strong national institutions – weak to non-existent national institutions.
- Forward-thinking Water Legislation – antiquated Water Legislation.
- Strong CMAs – non-existent CMAs.

It is easy to be seduced into thinking or wanting to believe that a particular 'flavour' or 'flavour combination' predicates good groundwater governance. It seems 'intuitively obvious' that abundant data and modern hydrogeology are prerequisites for good groundwater governance. However, the data from global case studies do not support this, and are 'counter-intuitive'. In Yemen, some examples of good groundwater governance exists based on respect for tribal law and centuries-old rules regarding well-spacing, and often enforced using peer pressure. In contrast, in the United States, the abundance of hydrogeological data and science has had very little impact on the governance of the Great Plains aquifer system.

Thus the particular 'flavour combination' one is dealing with should not be confused with good groundwater governance. For any particular 'flavour combination' both good and bad groundwater governance are possible. In order to isolate the 'essence' of good groundwater governance one has to look beyond governance 'flavour combinations'.

8.2 Limitations of investigation

8.2.1 INTRODUCTION

This investigation encountered limitations in the attempt to delve 'deeper' into the groundwater governance process as well as the identification of key interventions

for good groundwater governance. The primary limitations affecting this project were (a) a lack of global examples and evidence of good groundwater governance; (b) the high dependence on the opinion of one person (the principal researcher) for the backcasting analysis; and (c) naive expectations of what an implementing bureaucracy can realistically implement.

8.2.2 LACK OF EMPIRICAL EVIDENCE OF GOOD GROUNDWATER GOVERNANCE

The lack of evidence of good local groundwater governance makes it very difficult to justify any particular approach to improving groundwater governance. If there are no empirical grounds to substantiate a particular approach, then there are no grounds to justify a particular research or design approach. For these reasons only an exploratory approach could be applied to the study.

However there is a difference between an exploratory approach that takes notice of existing work and evidence and builds on it, and an exploratory approach that ignores existing work. It was observed in the global literature on groundwater governance research that there is a reluctance to build on what has been proven. Instead researchers have chosen to 'do their own thing'. Although the ODP are 'tried and tested', few studies on good groundwater governance have used them. For example:

Faysse et al. (2014) correctly note that the ODP give no guidance on how these principles should be implemented. This is then used as a rationale for ditching the design principles and attempting to improve local groundwater governance via social learning. Yet the design principles and social learning are not mutually exclusive. A more nuanced solution would have been to make use of social learning using the design principles.

López-Gunn (2012) argues that positive social capital underpins the ODP, but then does an in-depth analysis of case studies using social capital without using the design principles.

Ross and Martinez-Santos (2010) argue that the ODP are relevant but that sustainable groundwater governance depends on adaptive management and strong collaboration between various stakeholders. However Ostrom (2005) clearly identifies the importance of adaptive management and the role of the design principles in giving effect to adaptive management. It could rather be argued that the ODP are relevant and this includes sustainable groundwater governance depending on adaptive management.

Pahl-Wostl et al. (2010) have developed the 'Management and Transition Framework' (MTF) specifically for the analysis of the governance of water systems. The MTF was adapted by Knüppe (2012) for a study of groundwater governance. In effect, the ODP could be regarded as one of the 'grandparents' or even 'great-grandparents' of the MTF. However, while an institutional researcher or designer can easily utilize the design principles, the complexity of MTF appears to demand supervision from its founding university, the University of Osnabrück. A subset of the design principles, specifically designed for groundwater, might have more universal appeal than yet another framework.

Foster et al. (2010) acknowledge that the ODP provide the 'outline structure' for the approach advocated by them to improve groundwater governance, yet then provide a check-list of top-20 benchmarking criteria based on their collective expertise that may or may not be collected to the design principles. A simple comparison of which bench-marking criteria gives effect to which design principle and vice versa would have been very helpful.

In order to make a 'deeper' analysis, this investigation favoured the ODP. The ODP were chosen over more general rules and guidelines intended specifically for groundwater governance, such as those proposed by Custodio and Llamas (2003), and those by Foster et al. (2010). The reason for this is that the ODP have been subjected to more empirical testing than the more groundwater-specific rules. The benchmarking criteria (Foster et al., 2010) and the 'pillars' on which detailed governance structures can be built (Custodio and Llamas, 2003) appear to be based primarily on expert opinion, rather than empirical studies. This is not to say that in the long-term the Foster et al., and Custodio and Llamas criteria may prove to be more useful and relevant to the implementation of groundwater governance systems than the ODP. The position of this report is that (currently) the ODP have more empirical backing than the principles formulated specifically for groundwater, and are therefore more appropriate for this investigation.

8.2.3 NAIVE EXPECTATIONS AS TO WHAT A BUREAUCRACY CAN ACTUALLY IMPLEMENT

Many studies sorely lack substantial and concrete conclusions. They either suggest a multitude of things that need to be implemented and/or provide vague insights like 'improve vertical integration.' This study attempted to avoid this by ruthlessly narrowing down issues until specific interventions had been identified (interventions that could be implemented at the local scale). The interventions are relatively specific and modest. Even though the local case studies focused on identifying one intervention that would be the most useful and straightforward to implement. This does not mean the intervention would or can be implemented (in the current landscape). In the case of the Northern Sandveld, the study advocated the apparently modest intervention of sharing DWA monitoring data with the Northern Sandveld WUA and allowing the WUA to have inputs to DWA monitoring. However, given the current 'climate' at the DWA, it seems highly unlikely that this very modest intervention could or would be implemented.

Many studies make the assumption that a public service organisation exists to serve the public. This is the ideal but is not always the reality (many of us have real-life experiences that demonstrate that this is not the case e.g. a visit to a public health facility, a visit to a Home Affairs office). Public service organisations do not always have the understanding or will to use useful tools to make interventions that will better serve the needs of the public. Many Public Service actions are governed by attempts to justify their organisation's existence rather than to serve the public (Meyer and Rowan 1977). While little academic material is available on the functionality of DWA it is suggested that it is (probably) no more functional than other services. It is likely that it meets the normal standard for the South African Public Service. The 'norm' has been described by Von Holdt (2010) and Manuel

(2011) as essentially dysfunctional, with excessive regard for petty administration, and little regard for service delivery.

Unfortunately, if the descriptions provided by Von Holdt (2010) and Manuel (2011) are correct, then the DWA may not be the ideal implementer of any solutions (adaptive management, social learning, and increased social capital). It would therefore appear that if groundwater governance is to be improved it must be driven by an organisation or agency outside of DWA. The driving agency must seek to build social capital both at the local, WUA level and at the higher institutional level such as DWA.

8.3 Social Capital and building on something that works

This recommendation may seem ‘flimsy’ but may be the study’s most profound recommendation. Empirical evidence does exist for this recommendation. Where a functioning local water institution does not exist, it may be possible to utilize the ‘services’ of an existing local institution (that may be unrelated to water). Theoretical evidence to support this recommendation does exist (López-Gunn, 2012), since good governance is comprises a high degree of social capital (amongst other attributes) and it is easier to build on pre-existing social capital than it is to create social capital from scratch.

This recommendation should be applied to the implementing agencies and not only the local WUAs. Higher-level institutions should attempt to initiate effective local groundwater governance by building on aspects of their system already work, rather than attempting to design and implement a 'perfect' system from scratch.

Unfortunately, this approach would be 'messy' and is likely to experience a degree of failure. However, it is an approach that does offer hope.

8.4 Key Interventions as Leverage Points

Any proposed intervention or strategy will obviously have a large hypothetical component to it until it starts being implemented. Until it is implemented a 'good' strategy is no more superior to a 'bad' strategy since both are hypothetical. It is far easier to take a strategy and 'improve' on it rather than tackle the uncomfortable task of implementing that strategy. The interventions proposed by this investigation are intended to be as implementable as possible, but this does not guarantee that they can or will be implemented.

It is argued that the interventions proposed by this investigation are the *most* implementable that could be found. They are certainly *more* implementable than national water strategies and plans that pay little or no attention to implementation strategies.

The interventions proposed are relatively modest: no radical changes to laws are required. No massive introductions of capital are required. But *if* these interventions are implemented the ensuing gains are likely to be large. Thus the interventions are suggested 'leverage points' where a very modest input could lead to a very major improvement to the system. However, it has to be accepted that identifying the

leverage points where interventions would be most effective in no way guarantees that the interventions will be implemented.

8.5 Polycentric local groundwater governance in practice?

Polycentric simply means many centres. For a particular WUA the design of the overall polycentric governance landscape is not the issue, but rather that for the particular groundwater unit in question the WUA is the centre of *that particular groundwater unit.* It is suggested that the governance of the WUA might consist of the following components:

- local consumptive and non-consumptive users of the resource.
- representatives from adjacent water resources – groundwater or surface water – that might interact with the resource in question.
- representatives from higher water institutions such as CMAs to ensure that national and CMA water polices involving equity, sustainability, etc. are adhered to.
- representatives from other local, regional and national institutions that might have concerns about how the resource is used.

This list is not meant to be exhaustive or prescriptive but just to provide some introductory thoughts on how a WUA might be constituted.

The closest existing structures that resemble this polycentric approach are not CMAs or WUAs but groundwater Monitoring Committee. The Hermanus Monitoring Committee has been described in this report. In its heyday the Saldanha Monitoring Committee (Du Plessis, 2009) provided another good example. Representatives from different DWA Directorates ensured that their Directorate's concerns were addressed. It was not unusual for different Directorates to have different viewpoints. While this sounds a horrible mess it did work. Even though the Saldanha Monitoring Committee had no statutory power it did make decisions, and these decisions were adhered to by DWA and the West Coast District Municipality. For example, the District Municipality agreed to a reduction in pumping rates as recommended by the Monitoring Committee.

However, the District Municipality is now turning to desalinisation rather than groundwater and the momentum of the Monitoring Committee is fading. However Monitoring Committees do provide a useful model on which local groundwater governance could be built, rather than trying to design something ‘from scratch’.

8.6 Addressing the inequities of the past without abolishing WUAs

The National Water Policy Review (NWPR) (DWA, 2013) puts the case for the abolishing WUAs. The main rationale appears to be that they have been ineffective, have done little to redress the inequities of the past, and/or have been taking on water management responsibilities that higher institutions deem to be inappropriate.

The NWPR's diagnosis of the problem is not disputed. However, it is suggested that simply 'sweeping the problem off the table' by abolishing WUAs might not be the wisest solution. It is not that difficult to get rid of something that doesn't work. It is manifestly more difficult to replace something that doesn't work with something that does. For example, it is difficult to imagine the voices of the previously disadvantaged that are not being heard or are being ignored at a WUA, being given any more attention in a CMA covering a vast area and with a host of problems to deal with.

One of the major insights of this investigation's exploration of groundwater governance is the role of social capital. It seems reasonable to assume that social capital does not just apply to groundwater governance, but to all forms of governance, including surface water.

It is suggested that before one makes a decision on whether to abolish WUAs, one should first ask: 'what would be the best way to increase social capital?'

WUAs may be largely ineffective and/or inequitable at the moment. But they do have a certain amount of social capital (Jonker et al., 2010). They are capable of certain useful functions. If the WUAs are abolished that social capital will be lost. In addition the social capital may well become negative as the (ex) WUA members become even less trusting of higher institutions. The threat of being abolished will already be destroying social capital.

It is understandable that a central government (or CMA) official would trust a fellow central government (or CMA) official more than an ineffective and/or inequitable local institution. But the question has to be asked of whether the social capital in the form of trust between fellow officials in a higher institution will increase the overall social capital of the 'governance system' and so more than offset the social capital that will be lost when local institutions are abolished. It is suggested that this is unlikely to be the case, and that abolishing local institutions such as WUAs will lead to a net decrease in social capital.

However, it is accepted that the status quo is unacceptable. What is needed is a process to address the inefficiencies and inequities in a way that *increases* rather than decreases social capital. In other words what is needed is a system whereby there is trust between local users, *and* between local users and higher institutions. It is suggested that polycentric governance rather than reduced decentralization would be the best way for this trust to be built up.

In such a system a local resource is not just subject to governance by local users and stakeholders, but also by: (1) adjacent local users and stakeholders; (2) CMAs and regional institutions; (3) national institutions. These adjacent and higher institutions would have representatives that were member of the WUA and thus have *direct* inputs into the management of the local resource, rather than relying on, and hoping that, hierarchical-based strategies would filter down to and be adopted by the WUA.

Rather than abolishing these local institutions such as WUAs so as to 'eradicate' unfair practices, DWA would achieve more by providing support to the previously disadvantaged so that their voices are fairly heard and acted on by the local institutions. This is how social capital can be further increased. DWA learning to trust

local institutions because they are involved with them and have a direct say in their running. Local institutions learning to trust DWA because rules and procedures are being followed, and because they have real human beings to interact with instead of distant, faceless, and uncaring officials.

8.7 Ostrom Design Principles (ODP) are not a panacea

This report and groundwater governance researchers have all repeatedly made the point that there are no panaceas when it comes to groundwater governance. Ostrom herself has repeatedly made the same point for CPR in general. It would therefore be ironic if the ODP were to be become the next panacea.

This report has highlighted the ODP as a useful tool because they have been 'empirically tested' unlike some more specific groundwater rules and principles that are based on expert judgement. Testing in this case means that the ODP have been compared with 91 case studies of CPR governance. The comparison showed that there was a good correlation between the number of ODP present and good governance. However in none of these cases studies was there a deliberate and conscious attempt to implement the ODP. The overseers of each CPR had arrived at a governance system by trial and error, and researchers subsequently found that those governance systems that worked had all or most of the ODP present.

As far as is known there has been no conscious attempt to implement the ODP anywhere in the world. Thus one should be very wary of saying that implementing the ODP is any kind of panacea. Trying to implement something that *will* work is a very different arena that observing something that *has* worked.

These caveats suggest that attempts to deliberately implement the ODP via a pilot approach would be a very fruitful area of future research. The proposed key interventions suggest an approach for carrying out this pilot project.

9 CONCLUSIONS

1) Attempts by higher levels of government to unilaterally implement direct management of groundwater will almost certainly fail.
2) There are no general panaceas for good groundwater governance: Public, Private and Common Pool governance does not, of itself, predicate governance success. While it would appear that local stakeholder participation is a prerequisite for good local groundwater governance, it is far from a guarantee. And while there may be isolated instances of good local governance evolving without the support of an external agency, healthy support from an external agency / higher institution does seem to greatly improve the prospects for good local groundwater governance.
3) There are also no *specific* panaceas, no blueprints that will ensure effective local groundwater governance. A specific tool (for example 'education and awareness programmes) may be associated with good groundwater governance in some cases, be absent in other cases, and be present in some cases where groundwater governance is described as ineffective.
4) There are, however, general guidelines that may be of value in identifying which specific details need to be attended to improve local groundwater governance in a specific setting. The details will however be unique for that setting. The general guidelines include the ODP, the World Bank's 20 benchmarking criteria, and the governance 'pillars' or foundations provided by Custodio and Llamas. Only the ODP have been extensively tested empirically and evaluated in academic literature. However the ODP testing was for governance systems that were created by the resource users through trial and error, rather than for systems created by deliberate implementation by an external entity.
5) This investigation suggests that social capital may be the key concept underpinning good groundwater governance. Polycentric governance appears to be a viable route for improving social capital.
6) This investigation sought out key interventions to improve local groundwater governance by using a backcasting approach combined with the ODP.
7) The proposed interventions require a change of attitude to local groundwater governance, or a change of mental and conceptual models of local groundwater governance, more than they require changes to laws, science and institutions.

10 RECOMMENDATIONS

1) The key interventions recommended by this project are:

KEY INTERVENTION	RESPONSIBILITY
A 'one-step-at-a-time' approach whereby in a given local setting attention is given to the implementation of one Ostrom Design Principle at a time. The design principle selected should be the one that would be most beneficial to the local stakeholders and the most feasible for the external agency to assist with	DWA and/or WRC and/or Tertiary Education Institutions and/or National Groundwater Governance Association
Initiatives to improve local groundwater governance should take cognizance of, and be guided by, the need to improve social capital at all levels	National Groundwater Governance Association
Initiatives to improve local groundwater governance in South Africa should be driven by an agency/organisation outside of DWA. This agency could be the WRC, a university, or an NGO	'Charismatic' and/or motivated individual
Include a commitment to the Ostrom Design Principles in the GWS	DWA groundwater components

2) Test the implementability of the Ostrom Design Principles by carrying out one or more pilot projects using the 'one-step-at-a-time' approach.'
3) Reconsider the National Water Policy Review proposal to abolish WUAs. Groundwater is a local resource. It has to be managed locally. Investigate the benefits of increasing social capital via a polycentric governance approach, rather than decreasing social capital by abolishing local institutions.
4) View improving local groundwater governance as an ongoing, organic process rather than something that can be 'fixed' by a once-off intervention or the imposition of a specific governance design model.
5) The requirements and commitment needed to realise good groundwater governance are daunting. There is a very strong case for only attempting to improve local groundwater governance when there is a very strong need to do so, and essentially treating the remainder of the country's groundwater as a de facto private good.

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