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Views and Behaviours of Municipal Actors Relating to Climate Change and Water Management: The case of Local Municipal water management and Social Networks

MPhil specialising in Climate Change and Sustainable Development

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Declaration

I hereby declare that I have read and understood the regulations governing the submission of MPhil specialising in Climate Change and Sustainable Development dissertations, including those relating to length and plagiarism, as contained in the rules of this University, and that this minor dissertation conforms to those regulations.

Signed by candidate

Kristian Gerstner

11/02/2019

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Abstract

Climate change is projected to impact the hydrological cycle and have a negative effect on water supply. In South Africa, water to the end user is supplied by local municipalities, and thus municipalities are likely to benefit from adapting to these climate impacts. This research aims to understand the views and behaviours of local municipal actors towards water management and climate change, and how these views and behaviours influence the resilience of their water supply system in the face of climate change. A secondary aim of the thesis was to determine if the advice networks, where the actors receive the bulk of their information from, influenced the actor's views and behaviours around water management, climate change, and adaptation, using a social network approach.

The study area focused on five local municipalities in the West Coast District of South Africa. This research made use of a mixed methods approach, utilising both qualitative and quantitative data, obtained using semi-structured interviews with a structured component. Qualitative data were used to collect water management-related views and behaviours of municipal actors, whilst quantitative data were collected to determine social network characteristics.

The views and behaviours on water demand and supply management of the actors interviewed tended to differ. Actors' views on ideal water management approaches were more concerned with the long-term sustainability of water resources through raising awareness and managing existing infrastructure better. Actor's preferred behaviours however focused on immediate relief to water shortages, by augmenting existing supply and enforcing restrictions. These findings imply that actors respond reactively to drought, and not proactively. In terms of climate change, actors showed a clear understanding of climate change and its risks to water management. Actors understood how climate change adaptation could be used to make their municipalities' water supply more resilient, by utilising sustainable sources of water or through ecosystem-based adaptation, however it was found that municipal plans and behaviours did not generally reflect these views. Social network characteristics such as strengths of ties, and the existence of multiplex ties, did not appear to influence the sharing of behaviours or views between the actor and their given advice network. It was thus theorised that institutional lock-in and hierarchical governance might play a larger role in influencing views and behaviours than the actors' social networks.

The reactive responses by actors to issues of water demand or supply can lead to poor resilience in the face of climate change, where cases of drought and water shortages may become more frequent. Whilst municipal actors are aware of these changing conditions and risks, the limitations placed on them by governance structures and lock-in impact their ability to be proactive. More work needs to be done to ensure sustainable and resilient water management interventions are implemented at the local municipal level. Additionally, lock-in, both institutional and technological, could usefully be challenged to allow for innovative ideas to enter the realm of water management at the local municipal level.

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List of Acronyms and Abbreviations:

BM	Bergrivier Municipality
CC	Climate Change
CO_2	Carbon Dioxide
CM	Cederberg Municipality
CMA	Catchment Management Agency
DEA	Department of Environmental Affairs
DEA&DP	Department of Environmental Affairs and Development Planning
DWS	Department of Water and Sanitation
EbA	Ecosystem based Adaptation –
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
MM	Matzikama Municipality
n =	Number of respondents
NEMA	National Environmental Management Act (Act 107 of 1998)
NWA	National Water Act (Act 36 of 1998)
RCP	Representative Concentration Pathway
SBM	Saldanah Bay Municipality
SM	Swartland Municipality
SNA	Social Network Analysis
TCTA	Trans Caledon Tunnel Authority
WDM	Water Demand Management
WCDM	West Coast District Municipality
WCWSS	Western Cape Water Supply System
WSM	Water Supply Management
WUA	Water Users Association
x =	Strength of tie/tie characteristic

1 Introduction

There is general scientific consensus that increased atmospheric greenhouse gas emissions will result in global climatic change (IPCC, 2014). It is also widely reported that these changes will likely result in changes to the hydrological cycle, such as extreme drought or flooding (Kusangaya et al., 2013; McIntyre, 2012; UN Water, 2010; Mully, Dunne & Vecchia, 2005). The non-uniformity of the hydrological cycle will likely result in impacts ranging from extreme drought to extreme rainfall events leading to flooding (McIntyre, 2012). However, it is generally accepted that dry regions such as those in Southern Africa, will suffer severely from reduced rainfall and increased evaporation (McIntyre, 2012). Increasing populations, higher demand for food, and more water pollution will also all contribute to water scarcity (McIntyre, 2012).

Thopil & Pouris (2016) state that by the year 2025, an estimated >60% of the world's population will live in countries that have significant imbalances between water demand and supply. The African continent has been identified as the most vulnerable to climate change (Kusangaya, et al., 2013), and South Africa is ranked as the 41st driest country worldwide (FAO, 2016). Climate models show a reduction in annual precipitation across southern Africa and suggest that these changes would result in reduced water availability (Conway et al., 2015). Furthermore, it is expected that rainfall will occur less regularly in the south-western Cape of South Africa, with potential for high intensity rainfall storms increasing (Midgley et al., 2016). This would result in difficulty in capture and storage of surface water, resulting in impacts on water supply management.

The role of water management in South Africa differs between national and local government. According to the National Water Act (NWA, Act 36 of 1998), the national government of South Africa is responsible for and has authority over the nation's water resources and their use. The national Department of Water and Sanitation (DWS) is mandated to ensure that water resources are protected, managed, used, developed, conserved, and controlled in a sustainable and equitable manner, for all people and the environment (Department of Government Communications and Information System, 2018). This responsibility is divided into Catchment Management Agencies (CMAs) which are to manage water resources in defined water management areas, co-ordinate the functions of other institutions involved in water related matters and involved local communicates in water resource management (NWA, Act 36 of 1998). Currently only two CMAs are operational, with delays in implementation of CMAs being blamed on the slow delegation of functions, authorities and responsibilities, and delays in the transfer of funds (Department of Water Affairs, 2013). The responsibility for the provision of water related service is delegated to local municipalities (local government) by the Constitution of South Africa in section 152 (b), in which they are to provide services to communities in a sustainable manner. These services include electricity delivery, sewerage and sanitation, stormwater systems, and water for household use. The

financing of water related infrastructure and development falls on the Department of Water and Sanitation (national) through its Water Trading Entity, while the state-owned Trans Caledon Tunnel Authority (TCTA) finances and manages the implementation of water projects (Department of Water Affairs, 2013).

The key responsibility of water supply to end user is placed on local municipalities (Western Cape Government, 2013a), and thus local municipalities have an important role to play in meeting the challenges of water provision under a changing climate. In order to better understand the resilience, which can be defined as a systems ability to withstand stress or shock through absorption and adaptation (Rubin & Dahlberg, 2017), of local municipalities to climate change, specifically water management, it is important to understand the views and behaviours of key municipal actors involved in water management in municipalities. Furthermore, little is known about who these actors interact with for information on climate change adaptation and water management, and how these interactions may influence their views and behaviours when it comes to water management and climate change adaptation. These advice networks constitute a form of social network, which can be defined as a set of nodes, and the ties that connect the nodes (Brass & Krackhardt, 2012). Nodes can be defined as individuals, groups, or organisations and the ties can be defined as the relationships between these nodes (Marin & Wellman, 2014; Brass & Krackhardt, 2012). In analysing a social network, it is possible to study the relationships amongst the nodes in a network, and by so doing it is possible to determine aspects such as the spread of views and common behaviours among actors (Marin & Wellman, 2016), as various ties and their characteristics allow the diffusion of views and behaviours through a network.

Research on local municipal governments' views and behaviours around water management, climate change, and climate change adaptation is important in that it highlights potential areas where local municipalities are lacking in terms of their climate change planning around issues of water management. Furthermore, understanding how the social networks of key municipal actors potentially shape the decisions of these actors, assists in determining techniques to engage local municipal actors to shift their views and behaviours to be more resilient in the face of climate change.

1.1 Aim and objectives

The aim of this research is to explore the views and behaviours of municipal actors with regards to climate change, adaptation, and water management in order to better understand how municipal actors are coping, or intending to cope with, the projected impacts of climate change on their water resources. A secondary aspect of this aim is to determine how the social networks of actors may influence these views and behaviours. Five local governments within the West Coast District Municipality (WCDM) of the Western Cape Province of South Africa were used as case studies. The research objectives were as follows:

1. To determine the identified municipal actors' views and behaviours relating to water demand and water supply management;
2. To determine the identified actors' views of climate change and climate change adaptation, and their understanding of how it may impact water resources, and thereafter to determine how they would best utilise adaptation to overcome the projected impacts;
3. To determine the actors' advice network, defined as the five main individuals/organisations from whom actor receives the bulk of his/her information on topics of water management and climate change;
4. To explore whether the actors believe their views and behaviours are shared by their given advice network;
5. To combine the above objectives to further the understanding of how the views and behaviours of municipal actors relating to water management and climate change contribute to building resilience towards climate change, particularly in the areas of water demand and supply management.

2 Literature review

The role of the literature review chapter is to link this specific research to the broader literature on the topics of climate change, adaptation, water demand and supply management, and social network analysis. This literature review is broken up into two broad themes, namely: water resources and climate change adaptation, followed by the topic of Social Network Analysis (SNA). Within the first broad theme the literature firstly covers the topic of water resources and climate change, which is followed by climate change adaptation, covering aspects of theory and existing research on these topics. Thereafter, the review covers the role of climate change adaptation in water resource management and the topic of water demand and supply management. The second theme begins with a review of existing literature on the concepts of network centrality, network strength, and network size, followed by a discussion on the concepts of Norms, Views, and Behaviours, and how these characteristics can spread through a social network. Finally, the literature covers the topic of how social networks can play a role in natural resource governance.

2.1 Water resources and climate change adaptation

2.1.1 Water resources and climate change

Increasing uncertainties caused by climate change and changing socio-economic conditions have caused water management to face major challenges (Pahl-Wostl, 2006). Freshwater resources are considered particularly vulnerable to climate change, and the impacts of climate change are considered to affect the quality, availability, as well as the destructive potential of water (i.e. through flooding) (Schewe, 2014). It is predicted that climate-driven hydrological changes will combine with other pressures on water resource management, such as population growth, and this hydrological change will hamper the ability of water service providers to provide adequate freshwater (Kundzewicz et al., 2008). According to the Intergovernmental Panell on Climate Change (IPCC), the projected changes to the water cycle as a result of climate change will vary around the globe (IPCC, 2013). Whilst predictions are uncertain, it is expected that mid-latitude and sub-tropical arid and semi-arid regions will likely experience less precipitation. Whilst the amount of precipitation may not decrease in all areas, the nature and timing of precipitation events is very likely to change (IPCC, 2013). These changes in the hydrological cycle will also impact water quality, further impacting the health of ecosystems and human wellbeing. If the observed climatic changes over the last century continue, then the potential impacts on water resources, such as decreased recharge and increased evaporation, are likely to increase in magnitude, diversity, and severity (Kusangaya et al., 2013:47).

De Wit & Stankiewicz (2006) state that climate change and its associated impacts will impact precipitation patterns and thus surface water, furthermore Wang et al. (2016) state that a warming climate will place additional stresses on water resources. However, impacts are not

only limited to just surface water resources, as groundwater resources will also be impacted by climate change. For instance, Taylor et al. (2012) state that climate variability and change will influence groundwater systems in both a direct and indirect manner, through recharge via precipitation and surface water interactions, as well as changes to groundwater use. Groundwater is becoming a more widely used resource, particularly as a tool for drought resilience. Un-monitored usage could have widespread impacts for groundwater systems (Taylor et al. 2012). Groundwater quality is likely to be impacted by rising sea-levels under climate change, causing saltwater intrusion into coastal aquifers (Oki & Kanae, 2006). Some researchers, such as Vörösmarty, Green, Salisbury, and Lammers (2000), argue that changes to land-use, owing to population growth and socio-economic challenges, put a far larger strain on water demand than the impacts of climate change. Vörösmarty et al (2000) state that the consideration of direct human impacts on global water supply is poorly articulated. However, one cannot ignore the effects of a changing climate and these impacts need to be considered in conjunction with one another to better understand future water vulnerability (Vörösmarty et al, 2000; Wang et al., 2016).

2.1.1.1 Water resources and climate change in the South African context

Van Jaarsveld & Chown (2001) argue that under a scenario where CO_2 levels double from pre-industrial revolution levels, there will be a considerable warming in the subcontinent of Africa, with the greatest warming in the northern parts of Southern Africa. However, rainfall predictions in the model were far more difficult to predict. The predictions suggested that the arid interior of South Africa is likely to experience heightened evapotranspiration rates, increased stresses, and more frequent flood events, whilst the southwestern regions of the country are likely to experience increased early winter frontal and orographic rainfall, implying that rainfall will fall earlier in the season, meaning adjustments will need to be made to surface water management.

According to the Department of Environmental Affairs (DEA) (2013), a warming of 2 to 4°C is projected for the South Western Cape of South Africa for the period 2080-2100, whilst in the immediate short-term future (2015-2035), a warming of 1 to 1.5°C is projected. These projections are based on the Representative Concentration Pathway (RCP) 8.5, whilst projections based on the RCP4.5 show significantly less warming. However, under both scenarios a pattern of drying and less rainfall is projected for the South-Western Cape (DEA, 2013). Further to this, Midgley et al. (2016) notes that complex mountain topography, ocean influence, and varied land use, result in a variety of meso-climatic conditions within the Western Cape, indicating that climate change impacts will be varied across the province. In terms of rainfall, it is expected that climate change will strengthen conditions giving rise to orographic rainfall in autumn and spring, whilst weakening conditions for rain-bringing storms in winter. Midgley et al. (2016) notes that current climatic models, due to the meso-climatic conditions of the Western Cape, tend to show evidence for both increase and decrease in annual rainfall. However, it is believed that on average across the Western Cape rainfall will

decrease, with the assumption that dry areas will continue to get drier, posing threats to areas along the western coast of the Western Province (Midgley et al., 2016).

South Africa is identified as being vulnerable to changes impacting on freshwater resources. Perennial rivers in Southern Africa are expected to lose volume and flow as a result of climate change, with the areas around Cape Town in the Western Cape of South Africa losing more than half of their perennial supply (de Wit & Stankiewicz, 2006). An example of South Africa's lack of resilience to climate change is evident in the drought that began in 2014 (Ngoepe, 2015), which continued in southern parts of the country until mid-2018. Five out of nine provinces were declared disaster areas in the Summer of 2015/2016 (Ngoepe, 2015). Wolski (2018) states that Cape Town, which is situated in the Western Cape of South Africa, and thus experiences similar rainfall patterns to those of the study area of this research, suffered a period of severe water shortages due to the city not having any water resources which were resilient to drought, especially a multi-year drought.

2.1.2 Climate change adaptation

Before reviewing adaptation in the context of climate change and water resources (section below), it is important to have an understanding and overview of the concept of adaptation and a brief overview of the etymology of adaptation. The IPCC defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Adapting to climate change involves adaptation on a biophysical level, as well as that of a social and psychological level (Simonet et al. 2002). Climate change adaptation, or rather adapting to a changing climate, is what spurred the evolution of the human species, and with it the many biological, psychological, and sociological advancements and adaptations that followed (Simonet, 2002). Current research into the field of climate change adaptation is once again considering these aspects of sociology, biology and psychology (Simonet, 2010). Thus, one can see that the field of climate change adaptation reaches beyond the realms of physical science and understanding of changes in weather and extreme weather events, to also consider the socio-economic aspects of climate change, as well as changes to ecosystems and the services they offer. Adaptation also plays a role in reducing vulnerability to climate change in societies. Vulnerability can be defined as "the state of susceptibility to harm from exposure to stresses associated with environmental and social change, and from the absence of capacity to adapt" (Adger, 2006, 268). This definition shows that vulnerability can be broken down into three clear aspects, these being: exposure, sensitivity, and adaptive capacity (Adger, 2006). Ziervogel, Shale, and Du (2010) quote Brooks and Adger (2004), in stating that adaptive capacity is a system's "potential and capability to change to a more desirable state in the face of the impacts of climate change".

2.1.3 Adaptation strategies in the water resources sector

Various approaches to adaptation are relevant to this study. For the discussion that follows on the concept of adaptation strategies to climate change, Hallegatte (2009) is drawn upon. Hallegatte (2009) argues that many decisions regarding long-lived investments, such as bulk water infrastructure, need to consider climate change. However, this is not always an easy task, as the rate of climate change means new infrastructure will have to cope with a large range of changes, and secondly, there is a great deal of uncertainty in future climates, which makes model input difficult to incorporate into infrastructure design. It is therefore suggested that future infrastructure should be made more robust, i.e. the least sensitive, to possible changes in climate conditions. An example of this would be to utilise water resources which are less likely to be impacted by climate change, such as waste-water re-use, and conjunctive use between ground and surface water. Hallegatte suggests that users of climate change information must adopt "uncertainty-management", i.e. bringing in measures of uncertainty into their planning, when developing future infrastructure. He (or she) suggests five different strategies of adaptation, which are discussed below.

The first of the five strategies to be discussed is that of the "no-regrets" strategy. A no-regrets strategy is one that will give positive benefits even in the absence of climate change (see also Callaway, 2004). In the context of water management, an example of such a strategy would be that of controlling leakage in water systems. This adaptation method is always considered a good investment from a cost-benefit analysis point of view, even in the absence of climate change related impacts. The second adaptation strategy involves adaptation options which are easily reversible. The aim of these strategies is to keep the cost of being wrong about climate change as low as possible. Examples of such a strategy are technological or infrastructural changes which are "easy-to-retrofit". This strategy would involve options such as climate-proofing existing buildings and infrastructures, which may have an immediate cost, but can be stopped instantaneously if new information shows that the action is unnecessary. An example of an easily retrofitted adaptation strategy is restrictive planning, whereby the option to construct on, or develop in an area, is held back until it is absolute certain that the risks of climate change can be avoided. The alternative to not waiting and allowing the development to go ahead may yield short-term benefits, but may also result in costly protection, or retreat, for the development should climate change become an issue. The third strategy discussed by Hallegatte involves adaptation options which include a "safety margin". These options are intended to reduce climate change vulnerability at null or low costs. This strategy works by implementing changes to projects in the design phase, such as designing a stormwater system to deal with increased precipitation and run-off, by increasing the size of stormwater intakes and culverts. In this case, the cost of increasing the size of a stormwater system in the design phase is relatively low, compared to modifying an existing system. There is also no negative environmental consequence to altering the stormwater system, and it can provide various other positive feedbacks such as allowing for capture and storage of stormwater runoff. Furthermore, there are various ecological engineering approaches to

stormwater design. Ecological engineering is synonymous with the more popular "green infrastructure" term, in which natural approaches are used to deal with urban and climatic issues (United States Environmental Protection Agency, 2018). Yang & Li (2010) use the term "ecological engineering" when giving the example of an open drainage design, utilising permeable soils and ecological design processes to allow for better infiltration into the ground. This results in a similar response to rainfall as streamflow would in a wooded area, where stream flow does not necessarily increase and can handle more intensive rainfall (Yang & Li, 2010). As a further example of the safety margin strategy, if one were to construct a dike to cope with storm surges, it may be worthwhile building the dike higher than originally planned, so that it may cope with potential future sea-level rises. Fourthly, Hallegatte discusses the concept of "soft strategies", i.e. strategies which are more institutional or financial in nature. These can vary, for example, from better early-warning and detection systems, to insurance designed to assist people living in flood or cyclone high-risk areas, or insurance designed for farmers operating in areas which are prone to drought. Hallegatte (2009) provides the example of implementing an early-warning system with efficient evacuation plans for residents living in an area at high risk to hurricanes or storm surges, along with an insurance scheme and recovery plan to assist with recovery and reconstruction of the area as soon as possible. In South Africa a scheme like this would assist disaster management authorities in areas such as informal settlements, which have been identified as being vulnerable to climate change induced disasters, such as flooding (Ziervogel, Johnston, Mathew, & Mukheibir, 2009). An early warning system would allow authorities time to check infrastructure such as stormwater drains for blockages and alleviate the impacts of flooding, as well as prepare aid for people impacted by the disaster. The fifth and final strategy laid out by Hallegatte consists of reducing the lifetime of investments in high-risk areas. This strategy assists in dealing with uncertainty and the corresponding costs. An example of such a strategy would be to build less expensive housing in areas which are prone to flooding, rather than high-quality housing designed to last for 100 or more years.

With the above adaptation approaches in mind, this study considers water management strategies broadly, including both demand-side management and supply-side management strategies. Demand-side management can be defined as any measure, initiative or intervention, which may result in a reduction of expected water usage or demand from a consumer. These can be related to the "soft-strategies" discussed above as they demand side strategies are normally institutional or financial in nature, as well as by reducing the lifetime of investments in high risk areas (Hallegatte, 2009), by shifting high intense water use practices out of those areas. Supply-side management is defined as any measure or initiative that will increase the capacity of a water resource or the ability of a supply system to supply water (Rabe et al., 2012). Supply-side adaptation strategies can fall into the categories of easy-to-retrofit, no-regrets, and safety margin strategies, as discussed above (Hallegatte, 2009). Easy-to-retrofit may include adapting existing infrastructure, such as stormwater drains, to cope with more intense rainfall events, whilst a no-regret strategy, as mentioned

above, can involve improved maintenance or upgrading of existing infrastructure. Safety margin strategies would likely involve increasing available supply through sustainable sources, even if not currently needed, to ensure that future needs are met, and risks accounted for.

The adaptations which play a role in demand-side and supply-side management can manifest in infrastructural and technological adaptation, such as waste-water re-use, and various managerial approaches to water supply and demand management such as improving maintenance and making funding available for local small-scale resilience projects for water supply. Ecosystem based Adaptation (EbA) can also play an important role in adapting supply side management. A brief definition of EbA, taken from Munang et al. (2013), is as follows: "EbA is an approach to adaptation which harnesses the capacity of nature to buffer human communities against the adverse impacts of climate change. This is done through the sustainable delivery of ecosystem services" (Munang et al., 2013: 1). An example of EbA would be the clearing of alien vegetation from waterways, thereby improving flow and water levels, thus increasing the amount of water which can be abstracted from waterways.

Occasionally, adaptation strategies can be implemented incorrectly or fail to achieve their objective. This can lead to "maladaptation", which Magnan (2014; 3) defines as "a process that results in increased vulnerability to climate variability and change, directly or indirectly, and/or significantly undermines capacities or opportunities for present and future adaptation". This maladaptation could be the result of projects that do not integrate broader development challenges such as population growth, development, urbanisation, or in some cases, simply lacking the required climate change information to make informed decisions (Baudoin, 2016). An example of maladaptation to drought is raised by Christian-Smith and Levy (2015), in which they show that the coping strategies adopted by California during their multiyear (2007-2009) drought had a negative impact on the vulnerability of various aquatic ecosystems and social groups that rely on these ecosystems for their health or employment. A strategy implemented involved increased groundwater abstraction, which resulted in a marked decrease in the water-table, impacting existing users and resulting in boreholes that had to be drilled deeper, requiring stronger pumps, equating to more energy requirements and greater greenhouse gas emissions. Furthermore, during the drought there was a large loss of hydropower, which resulted in the government of California looking into the purchase of natural gas, which resulted in the release of harmful pollutants and particulates.

Gill et al. (2007) attempts to find an approach to water management which is less prone to maladaptation. Gill et al. (2007) suggests incorporating "green infrastructure" to adaptation, which can be defined as a planned network of natural and semi-natural areas, with environmental features designed and managed in such a way that they deliver a range of ecosystem services (European Commission, 2013). Ecosystem services can be defined as benefits humans obtain from ecosystems, such as fresh water, food, fuel and fibre, biological products, waste management, regulation of infectious disease, cultural, spiritual and

recreational services, and climate regulation (Allaby, 2015; Millennium Ecosystem Assessment 2005). Ecosystem services also play in intrinsic role in the well-being and health of humans all over the world (Millennium Ecosystem Assessment, 2005). Green infrastructure development incorporates EbA-based options such as clearing of water-ways of alien and invasive species to improve river base-flow, managing groundwater sources through measures such as managed aquifer recharge, whereby water is pumped back into aquifers to prevents the lowering of the water table to unsustainable levels (Casanova, Devau, and Pettenati, 2016). Maintaining healthy ecosystems in the face of global climate change is essential in creating resilience. On a global scale, EbA approaches have been shown to be cost-effective, and have a host of co-benefits, whilst conserving biodiversity (Environmental Resource Management Department, 2011). Thus, not all approaches to supply-side management can be risky in terms of maladaptation and combined with demand-side approaches can be far more sustainable than traditional approaches to water management, such as building dams and abstraction from surface water sources.

2.1.4 Water demand management and water supply management in South African local government

2.1.4.1 Demand and supply management

The Global Water Partnership (2012) defines Water Demand Management (WDM) as a process which seeks to encourage better use of existing water supplies through efficient management and economic measures, prior to increasing available supply, whereas Water Supply Management (WSM) looks to increase or improve available yield of water. This section of the literature review first covers what is done in the Western Cape region of South Africa with regards to WDM. Thereafter, this section of the literature review will look at WSM and bring in what is done in South Africa.

WDM makes use of several interventions and systems, which can include technical, social, economic, environmental, and institutional changes, to promote the sustainable usage of existing water supply (Global Water Partnership, 2012). Technical aspects can include improving irrigation methods and efficiency thereof, utilising crops which require less watering, and improving canal streamflow, whereas economic incentives can include pricing (i.e. stepped tariffs), quotas (free water to households below a certain income), and where necessary fines for excessive use. Institutional interventions can involve water policing, reporting of irresponsible usage, and issuing water use authorisations and managing offtakes through licencing and registrations (Global water Partnership, 2012).

In terms of WDM, the main historical approaches utilised within South Africa, as stated by the DWS (2016), are education and awareness campaigns and implementing water restrictions. Jeffery (2006) and Fielding et al (2012) have shown that education and awareness campaigns can have a short-lived effect. However, measuring the actual effectiveness of these campaigns is not always possible as these campaigns are rarely run independently of other

water saving measures (DWAF, 2007; Inman & Jeffrey, 2006; Geller, Erickson, & Buttram, 1983). Fielding et al. (2012) show that education and awareness campaigns can be very effective in reducing water consumption, however, once ended, the effect tends to not last beyond twelve months. Contrary to this however, Syme, Nancarrow & Seligman (2000) state that educational and awareness campaigns have been used on a long-term basis to maintain a conservation state-of-mind surrounding water use. Furthermore, Syme et al. (2000) identify education and awareness campaigns as being able to reduce water consumption by up to 25% in times of crisis (i.e. drought). Fielding et al. (2012) state that in order for the success of an education or awareness campaign to be long-lived, they need to be continually run. Water conservation education campaigns are most commonly run in response to the onset of drought situations (Syme et al., 2000). Visser et al. (2019) discusses the role played by behavioural nudging to enact behavioural change in order to curb water usage at various Cape Town schools. Visser et al. (2019) showed that behavioural intervention through encouraging competition and weekly updates of how much water was saved, resulted in a reduction of between 15 to 26% in the schools. Further to this, an education and awareness campaign run by the local municipality of Knysna, in the Western Cape of South Africa, helped to reduce the municipalities water use by 30% during a drought period in 2009 (Rabe, Maree, Ramano, & Price, 2012). A public water savings campaign was identified by the municipality as the quickest WDM measure that could be implemented by the municipality to reduce water consumption. It is believed the campaign achieved a water saving of 39%, which helped the municipality maintain a sustainable water supply during the extreme drought conditions (Rabe et al, 2012). A more recent example is that of the "Day-Zero" campaign in the City of Cape Town, which was aimed at raising awareness to the severe water shortage as a result of the multi-year drought from 2015-2018. Hendricks and Gontsana (2018) quote various City of Cape Town ward councillors as stating that the roll-out of awareness campaigns, such as the announcement of Day-Zero, have been tantamount to reducing water use in the City, although no data is available to correlate the councillors' statements, which backs up Inman and Jeffrey's (2006) statement on how the effects of public awareness campaigns are often difficult to quantify. It would therefore appear that education and awareness campaigns can be effective at reducing consumption, particularly when used in conjunction with other measures such as water restrictions. However, the longevity of these campaigns needs to be considered and structures put in place to ensure their continuity outside of periods of drought and/or emergency.

Water restrictions are defined as measures undertaken by a municipality to restrict the demand for water by consumers (Rabe et al., 2012). The overall difference between water restrictions and raising awareness then is that water restrictions enforce a curb in demand through fiscal or legislative measures, whilst awareness and education campaigns are meant to encourage awareness and behavioural change through psychological means. It is believed to be easier for municipalities to implement water restrictions as they have the legislative tools to do so, however it may prove most effective to implement both restrictions and

education campaigns together when coming up with a WDM strategy. An example of this view is given by Rabe et al. (2012), who discusses the example of water restrictions being introduced in the municipality of Beaufort West in January of 2010. These restrictions shutting off water to certain areas for periods of time, to allow other areas to access water. This strategy ended up raising awareness as to what life without water would be like for residents, and thus resulted in resident reducing their consumption, which in conjunction with the water restrictions, ensured that water supply was maintained to the town. As a further example of combining awareness campaigns with other WDM measures, the City of Cape Town has shown that water consumption can drop up to 33% within a year, notably the year 2017/18, and 50% over three years (2015-2018) (Jones, 2018). Jones (2018) attributes this impressive 33% drop within a year to water restrictions, pressure reductions, and increasing tariffs (similar to water restrictions, but usually placed on curbing excessive use by charging excessive water users more per kilolitre) (Jones, 2018). Thus, the outlook of awareness campaigns being an effective long-term WDM measure is not clear cut and depends heavily on the implementation of the campaign (Rabe et al., 2012; Syme et al., 2000; Inman and Jeffrey, 2006), and it is shown that there is no one silver bullet for issues of WDM, and that numerous methods used conjunctively provide the best results.

An additional example of conjunctive uses to curb water demand is shown by the Overstrand Municipality, which has implemented a successful WDM strategy since 2007, combining various WDM measures to reduce water losses and consumption by users. Petterson (2016) reports that in 2008 water losses in the Overstrand municipal area were around 30% and were increasing, with the municipal council aiming to reduce this to 17% by 2017. The turnaround strategy implemented various measures, including the installation of smart leak detection and repairs, pressure management systems, utilising treated effluent for irrigation, structured water tariffs to curb excessive usage, and raising public awareness on water issues. These combined measures resulted in 21.1% reduction in water demand, and reduced water losses to 18.8% in 2015/16 (Petterson, 2016). Contrary to WDM is WSM, which looks at increasing available supply of water systems. We will now look at the literature on WSM related to this research.

In this research, WSM is defined as any measure or initiative that will increase the capacity of the water resource or water supply system to supply water to the end users (Rabe et al., 2012). Increasing water supply can be done through finding new sources of water, be they ground or surface water systems, diversion of water courses, increasing the capacity of storage, or using technology to create clean, potable water from what was previously an unusable source (Delfau, 2017). Within the context of the Western Cape of South Africa, the DWS (2016) identified various supply-side measures to increase yield in the Western Cape's water supply system. These included large scale groundwater abstraction, diversions of rivers into dams, increasing dam storage, implementing waste-water treatment and re-use, and small-scale desalination.

The usage of dams and diversion of water courses have for a long time been considered unsustainable and environmentally damaging (Baxter, 1977; Power, Dietrich, & Finlay, 1996; McCartney, 2009; Richter et al., 2010). Thus, alternatives such as desalination and waste-water re-use have recently been focused on as a way to increase the yield of water supply systems and provide more drought resilience (Mohsen & Al-Jayyousi; 1999; Scarborough et al, 2015; Gude, 2016; Porter & Sahin, 2016; Gude, 2017) However, these alternatives also have their drawbacks as discussed below.

Desalination has been noted as being unsustainable as a large-scale water supply intervention (Dolnicar & Schafer, 2009; Gude, 2016; Shazad, Burhan, Ang, & Ng; 2017) For example, Dolnicar and Schafer (2006; 2009) note that desalination held various environmental concerns as well as health concerns in a study on public perception of this water augmentation option, whereas Fritzman, Lowenberg, Wintgens & Melin (2007) and Gude (2016) shows that non-renewable energy sources and the high energy demand of desalination contribute negatively to the sustainability of desalination. Furthermore, Fritzman, Lowenberg, Wintgens & Melin (2007) state that desalination can be an expensive water augmentation measure, depending on the cost of energy, however, Scarborough et al (2015) shows that desalination in coastal cities in Australia can, in the long term, be more cost effective than building additional dams for capture and storage or rainfall. In South Africa, desalination has not been used on a large scale, however it has been used as a treatment measure to treat groundwater in the town of Bitterfontein, as the groundwater there is very brackish (Western Cape Government, 2018). Furthermore, three small desalination plants were built in Cape Town to augment the City's water supply during the 2017/18 drought. However, these plants have been fraught with difficulties and are often not running at full capacity (Liao, 2019; Pace, 2018).

Riemann, Chimboza, and Fubesi (2012) note that groundwater is not perceived as an important water resource in South Africa at a national scale and is thus not given the support it needs at lower levels of government. However, they note that most towns in arid areas depend on groundwater, either as a sole supply, or as an essential supply for drought management. Suvedi, Kreuger, Shrestha & Bettinghouse (2000) noted that usage of groundwater was only a concern in areas where the land-use type (i.e. farming, industry, etc.) is known to have an influence on groundwater quality. Furthermore, the risks of over-abstraction are well understood globally (Custodio, 2000; ; Llama & Martines-Santos, 2005; Eamus & Froend, 2006; European Environmental Agency, 2007; Faneca Sanchez et al, 2016; Griebler, Avramaov & Hose, 2019); common examples of these risks are saline-intrusion in coastal areas, where over abstraction in the aquifer causes salt water from the ocean to infiltrate the aquifer, and decreased river flow and drying out of wetlands which are sustained by groundwater. Further knock-on effects of groundwater over-abstraction include freshwater ecosystem destruction, land subsidence, groundwater quality degradation, and potential socio-economic issues such as impacting existing users. For municipalities to implement new water supply methods effectively, intensive impact studies of groundwater

abstraction must be done to determine and mitigate future negative impacts. However, if managed properly, groundwater can be very effective at increasing the municipal, or even national, supply of water (Hedden, 2016). Furthermore, groundwater is often ignored for large-scale urban reconciliation strategies, and in the opinion of Hedden (2016), is an overlooked resource.

Waste-water reuse and recycling has been successfully implemented in several locations around the world, both directly and indirectly. Direct reuse is defined as treated wastewater being utilised directly, without being diluted in a natural stream or groundwater, whereas indirect usage involves the treated wastewater being diluted (Ambulkar & Nathanson, 2019). Direct reuse has been occurring in Windhoek, Namibia, for around 50 years (Gross, 2016), and in Beaufort West in South Africa for around nine years (Gosling, 2018c). The New Goreangab Reclamation Plant in Windhoek was commissioned in 2002 and produces around 21 000m^3/day, whilst the older plant produces 4 800m^3/day (Menge, 2010). In Beaufort West wastewater reuse was implemented as a measure for drought alleviation, when in 2011 the Gamka Dam dried up during a drought, and the town was forced to apply for emergency funding from the national government for the construction of a wastewater treatment plant for potable use (Matthews, 2015). No more than 30% of the towns water supply is reclaimed water (Matthews, 2015). For the most part, public acceptance of waste-water recycling has been identified by several authors (Hurlimann & Dolnicar, 2010; Ulmann & Head, 2011; Aitken et al. 2014; Fielding et al. 2018) as being key to the successful implementation of waste-water recycling as a water supply intervention scheme. Fielding et al. (2018) notes several factors which contribute to public opposition of waste-water recycling, these include perceived health risk concerns, distrust in the authority's management abilities, a lack of information in media and in the public domain, religious beliefs, and a "yuck" factor. These yuck factors appear to play a role in both indirect and direct recycling schemes, whereby direct schemes inject treated effluent straight into the supply system, whilst indirect schemes utilise treated effluent to recharge groundwater and surface water systems. Hurlimann & Dolnicar (2010) look at an indirect recycling scheme in which it was proposed that treated effluent should be pumped into an aquifer to act as an artificial recharge method to mitigate groundwater abstraction from the aquifer. Even within this scheme, public opposition was strong, because of various health, environmental, and even image concerns, in which residents were concerned that the scheme would damage the image of their town. Ulmann and Head (2011) looked at various cases of direct measures of water recycling, in which effluent was to be treated to a drinkable standard and injected directly into potable supply. In each case, public opinion of waste-water recycling was negative because of perceived health risks, distrust in management, religious taboo, and a definite "yuck" factor. Matthews (2015) argues that an effective way to mitigate against the yuck factor is to implement a comprehensive monitoring programme, communicate results effectively, and raise awareness about the benefits of water reclamation.

2.1.4.2 The South African local government context of water management

Water governance is legislated in the National Water Act (NWA) (Act 36 of 1998) of South Africa. A person may only use water if permissible under the act, and chapter 4 of the NWA lays out the basis for regulating water use. A key challenge of South African water legislation in a post-apartheid setting was to transform away from apartheid water injustices (Clifford-Holmes et al., 2016). Clifford-Holmes et al. (2018) states that water governance and management in post-apartheid South Africa has been fundamentally redesigned by the national government. A key aspect of this redesigning effort has been to decentralise the decision-making of water governance, more inclusive governance and management, and integrating environmental, social, and technical dimensions into water governance. However, implementation of the NWA has been challenging, and as stated by Clifford-Holmes et al. (2018), the roles of local government and their functions needing to be re-assessed.

The NWA is regarded as ambitious by international observers, as well as forward thinking, and has broad aims of integrated water resource management. Regulating water resources and protection of these water resources is fundamental in adaptation to projected climate change impacts. Due to the very broad scope of water management, it needs to be delegated down to local levels. Thus, chapter 7 of the NWA deals with catchment management agencies, which delegate water resource management to the regional or catchment level and involve local communities. Finally, chapter 14 deals with the monitoring, recording, assessing, and dissemination of information on water resources, which is of critical importance to achieving the objects of the act and the sustainable use of water resources. Demand side and supply side management, as defined earlier by Rabe et al., (2012), are key aspects of municipal water management.

On a national and provincial level, processes to protect and enhance the supply of water resources are written into South African legislation and policies. For example, water conservation and demand management are a focus area of the Western Cape Provincial Spatial Development Framework (Western Cape Government, 2014). This focus serves to ensure that there is sustainable use of provincial assets such as water, thus the Provincial Spatial Development Framework aims to mainstream water conservation and demand management in settlement making and upgrading. For clarity, a Spatial Development Framework is a framework that guides overall spatial distribution of current, as well as desirable, land uses within a municipality, city, or province. Municipal Spatial Development Frameworks need to be developed in line with the Provincial Spatial Development Framework and national development plans, as legislated by the Spatial Planning and Land Use Management Act (Act 16 of 2013). The development of Municipal Spatial Development Frameworks in line with Provincial Spatial Development Frameworks is to ensure protection of resources and, in the case of climate change, ensure adaptation and mitigation is kept in mind alongside development and expanding of economic activities.

Climate change adaptation in terms of water management is of high importance at the municipal level. Whilst bulk level water supplies are often controlled by district government, with provincial and national governments playing a role, the actual supply of water to the end user is controlled by the local municipalities (Western Cape Government, 2013a). The Department of Water and Sanitation (DWS) (2015) conducted a study on the status of water availability in all towns within the Western Cape. This study included a detailed analysis of each town within the West Coast District Municipality (WCDM). When looking at the WCDM, one can see that water supply is constrained across the district, with several towns already experiencing shortfalls. Thus, these municipalities need to ensure that supply to these towns is continued and well managed into the future.

2.2 Social Network Analysis

A social network, as mentioned in the introduction, is defined as a set of nodes, and the ties that connect the nodes (Brass & Krackhardt, 2012; Marin & Wellman, 2014). Nodes can be defined as social actors, either individuals, groups, or organisations, and the ties can be defined as the relationships between them. Social Network Analysis looks at determining the relationships between the nodes, not the attributes of the individual nodes. The analysis of social networks assumes that causation of behaviour and views is not located at the level of the node (e.g. an individual) but is rather located in the social structure of the nodes' (e.g. the individuals') network (Bond & Harrigan, 2014; Marin & Wellman, 2016). Common nodal attributes such as shared views, beliefs, and norms can lead to certain social behaviours, and result in this behaviour becoming socially acceptable (Bond & Harrigan, 2014; Marin & Wellman, 2016). Characteristics of the node's social networks are theorised to influence this (Knoke, 2014). As an example, an individual who associates more frequently with a network of individuals who share pro-environmental views and beliefs, is likely to adopt these views and beliefs, provided the characteristics of their ties with the individuals in the network support this. For example, if an individual feel positively about the other nodes in his/her network, is highly dependent on them, and interacts with them frequently, then he/she is likely to adopt their pro-environmental behaviours. These social network characteristics are explored in the sections below.

2.2.1 Strength of ties, homophily and network Size

Tie strength refers to the nature of the connection between actors in the social network (Haythornthwaite, 1996). Oftentimes, combinations of measurements such as frequency of contact, duration of the contact, intimacy of the tie (i.e. how the node feels about the other node), tie reciprocity (i.e. is the feeling shared), and measures of kinship (i.e. the type of relationship) need to be used to measure tie strength (Haythornthwaite, 1996). Krackhardt (1994) identifies three relational dimensions to measure the strength of a tie, namely dependency, intensity, and affect. Dependency is the measure on how strongly an actor relies on a tie to fulfil his/her role in the social network, or as a source of knowledge; intensity can

be described as how frequently the actor and the tie interact; and finally affect refers to how an actor feels about his/her ties, both positively or negatively. Krackhardt's work is discussed further in section 2.2.2.

Strong ties, such as a connection between friends, have been considered to be conducive to the exchange and flow of information, views, and behaviours; this exchange occurs because individuals who are more closely tied to others have more intimate ties, and are thus more motivated to share information (Haythornthwaite, 1996). However, Granovetter (1973) highlighted the importance of weak ties, such as the connection between acquaintances, showing that there are certain advantages to weak ties. His study on the strength of weak ties showed that 80% of respondents found their current employment through a contact they only rarely or occasionally saw; thus, weak ties play an important role in gathering new or novel information. Granovetter (1982) went on further to reconfirm the importance of weak ties for bringing novel information into a network, and strong ties for the exchange/spread of such new information within a network, thus embedding the importance of both strong and weak ties in SNA. However, strong and weak ties not only facilitate the introduction and transfer of information, they can also introduce and facilitate the sharing of views and behaviours, which is discussed below under the concept of homophily.

According to Leombruni (2015), homophily refers to similarity in norms, behaviours, and/or views among actors in a network. Norms are considered as social rules, whilst behaviours are what individuals do in response to an event, and views as how the individual sees the world. These definitions are covered in more detail further below. McPherson, Smith-Lovin and Cook (2001) state that homophily is the contact between similar people that occurs at a higher rate than among dissimilar people, i.e. birds of a feather flock together. For example, people of the same demographic (religion/ethnicity/social status) are more likely to share views, behaviours, and norms and thus bond together (Chen & Yong, 2015) Ties which are strong generally exhibit a stronger homophily, and thus share norms, views and behaviours more strongly. Further, the more types of relationships that exist between actors, e.g. two actors being both friends and work colleagues, the more strongly are views and behaviours shared between the actors. These mixed relationships are often referred to as multiplex ties (McPherson et al., 2001), and are theorised to be stronger than usual simplex (single relation) ties. One can then expect strong multiplex ties, exhibiting homophily, to be useful for the transferring of views and behaviours in a network. The size of the network also plays a role in how views and behaviours are transferred, and this is discussed in brief below.

Network size is quite simply the number of actors within a network. Size is very important in a network and can impact on factors such as the strength of ties (Hanneman & Riddle, 2014). For example, in a network of 12 actors, it would not be difficult for each actor to know the other well, and to build up relationships, however in a network of 300 this becomes far more difficult. Therefore, the larger a network, the less likely it is that views, norms and behaviours would be shared. Network size is also important at determining network density, which can

give insight to phenomena such as the spread of information through the network: the denser a network is, the quicker information will spread. Network density is defined as the sum of ties divided by the number of possible ties within the network (Hanneman & Riddle, 2014). Having reviewed selected social network characteristics important to this study, the discussion now turns to consider how views and norms can spread through a social network.

2.2.2 Views, behaviours and norms, and their spread through networks

Understanding norms, views, and behaviours within a network helps to determine the effect that the social network characteristics of the network may play on shaping an individual's actions. Behaviours and views are separate in the sense that views are defined as a way of seeing the world and dealing with it (Gray, 1985), and behaviour can be defined as anything a person does in response to internal or external events (Porta, 2014). The concept of social norms seems to have no clear standard for how they are to be understood (Peter & Spiekerman, 2011). Hart (1961) defines social norms as rules of obligation, and thus social norms come with an expectation to conform (Peter & Spiekerman, 2011). Cialdini & Trost (1998) state that norms are a psychological phenomenon which have widespread usage, as it helps describe and explain human behaviour. Caldini & Trost (1998) further define norms as "negotiated rules" for social behaviour, such as customs, traditions, standards, values, fashions, and all other criteria of conduct, which become standardised through the contact of individuals. The concept of norms can be further broken down into what is commonly done, and what is commonly approved of (Cialdini et al., 1991). Norms regarding what is commonly done are referred to as "Descriptive Norms", and norms that characterise what is commonly approved of are referred to as "Injunctive Norms" (Cialdini et al., 1991). For example, it may be commonly approved within a group that water conservation is important, and water wastage is frowned upon, thus a common behaviour that might be expected would be to have shorter showers. However, as noted by Chen and Hong (2015), this may not always be the case and discrepancies between what is commonly approved of, and what is commonly done, often exist.

Norms form part of institutional dynamics, and thus it is important in the context of this research to understand what is meant by an institution. North (1991) defines institutions as humanely devised constraints that structure political, economic, and social interaction. North (1991) looks at the various "constraints" that institutions form, such as formal rules (i.e. laws and rights) and informal constraints (sanctions, taboos, traditions etc.). These formal and informal constrains align with the concepts of norms in that descriptive norms relate to informal constraints, and injunctive norms relate to formal rules (Cialdini et al., 1991; North, 1991).

Several SNA studies have shown how views, beliefs, and norms can spread through a social network, such as the social influence model (Knoke, 2014), the network-effects model used by Ibarra and Andrews (1993), and Krackhardt's (1994) constraints on the interactive

organisation as an ideal type. Within Krackhardt's (1994) work, it is noted that the strength of a tie plays an important role in the dissemination of views and behaviours within a network, and the characteristics relating to the strength of the tie are discussed below. Related to climate change attitude and beliefs, a study by Leombruni (2015) looked at how attitudes and beliefs can be spread through a network and potentially influence government policy towards climate change, as well as community and individual climate-related behaviours. The study was primarily exploratory, yet shows how characteristics of social networks, for example tie strength, play a role in regulating behaviours and views within a social network (Leombruni, 2015). Leombruni's study demonstrated that a strong tie will likely result in the sharing of views and behaviours. However, Grafton (2005) shows that both strong and weak ties play an important role in social networks by enhancing feelings of trust and co-operation (strong ties) and allowing the diffusion of information, and new views and behaviours (weak ties). Thus, both strong and weak ties are important within a social network and a balance between both should be struck to create trust as well as foster new ideas and views.

As stated above, Krackhardt (1994) shows us that a strong tie can result in the spreading of views in a network, whereas a strong dependency on a node can lead to more frequent interactions (intensity, as measured by Krackhardt), and potentially a positive feeling (Affect) toward the node, and thus a sharing of views and/or behaviours. A person who is faced with a need for information, resources, or permissions, will try to fulfil their need by seeking out another person who may provide them with what they need. Should the dependency continue, so will the need to interact with that person Krackhardt (1994) also shows that a high intensity between the actor and the node can lead to a positive or negative evaluation (affect) of a tie. A strong affect will likely reinforce the relationship, whilst a negative affect will cause the relationship to falter and for the person to interact less frequently with a particular node. In situations where a positive affect is formed, a multiplex tie often forms.

Whilst strong ties are useful for the spread of views and behaviours in a network, weak ties are also useful within a network, as shown by Granovetter (1973). Weak ties play an important role in introducing new information and views into the network. Krackhardt's work highlighted the fact that networks are not particularly fluid, and in a network with strong ties, mostly highly dependent ties, the challenge of introducing new information, or views and behaviours, is great.

Decision making in government organisation often follows a process of hierarchical governance (Primmer et al, 2015). These sorts of top down relationships are often characterised by directed ties, which Finally, Marin & Wellman (2014) define as information-sharing, advice-seeking ties. Directed ties can be reciprocated in terms of information but can also be a one-way tie. For example, a Municipal Manager may instruct their engineers to work on a project, but this type of hierarchy cannot be reciprocated, and thus constitutes a one-way tie. However, in the case of advice and information-sharing, these ties can go both ways. As an example, an engineer may advise the municipal manager on a project, and the municipal

manager may offer budget advice to the engineer for the same project. Thus, directed ties play an important role in the flow of views and behaviours within a hierarchical governance type network, and in the case that ties can be reciprocated, allow for the spread of views both ways in a network.

The following section will look at literature on social networks and natural resource management, exploring concepts of network characteristics and how they link in with natural resource governance.

2.2.3 Social Networks and natural resource governance

The effects that the characteristics of a social network may hold on water management and climate change adaptation is a secondary aspect of this research. Thus, a review of related literature in this field assists in showing how this research sits in the field of natural resource management. Bodin and Crona (2009) show that the existence of social networks plays an important role in cases where stakeholders have joined to deal with natural resource problems. For example, in a network whereby the nodes all have similar sustainable practices in relation to a common-pool resource (i.e. water or fisheries), then it is likely that the stakeholders in the network will monitor one another's behaviours, thereby ensuring that conflict between nodes and misuse of the resource is resolved quickly or avoided (Crona et al, 2011; Grafton, 2005). Thus, social networks can be more influential than the existence of formal institutions in ensuring compliance with environmental regulations and can also ensure effective enforcement of these regulations (Bodin & Crona, 2009; Crona & Hubacek, 2010).

The nature of these social networks, in terms of frequency of interaction between nodes, nature of the relationship between nodes, and aspects of conflict, all play a role in how the various nodes in the network will approach natural resource governance (Bodin & Crona, 2009; Crona et al, 2011). Grafton (2005) shows us that the existence of both strong and weak ties in a social network are important in ensuring outcomes related to conservation and management when it comes to natural resource management. As discussed above, these strong and weak ties are important by bringing about trust and co-operation and assisting in the diffusion of new views and behaviours through a network and across networks, as well as entrenching established views and behaviours (Grafton, 2005). Crona (2011) states that views and behaviours around natural resource governance are more likely to be shared in the event that a tie is either strong or multiplex. However, strong social cohesion can lead to tunnel vision on the management of the resource. This may impact cases whereby diverse views and adjustments to common practices are necessary for the sustainability of the resource (Crona et al. 2011), and this is where weak ties also play an important role in allowing new views and behaviours to enter the social network (Grafton 2005).

Bodin et al. (2011) states that effective management of natural resources, such as water, relies on the knowledge, expertise, and the willingness for negotiation, conflict resolution,

collaboration, and coordinated action among various stakeholders. The construction of flexible and adaptable institutions, which can handle uncertainties and deal with issues of power, discourse, and conflicts, is fundamental in the way natural resources are managed (Bodin et al, 2011). In the case of South African water management, with so many role players and institutions involved, it is important to ensure that links between institutions involve both strong and weak ties, to facilitate co-operation as well as the diffusion of new views and behaviours.

2.3 Conclusion of literature review

The literature found that climate change, through impacts on the hydrological cycle, will have impacts on water resources. Adapting to these impacts has been considered as tantamount to ensuring water security and building resilience in water supply systems. Within the realm of water management in South Africa, it was found that strategies of increasing tariffs and raising awareness were the most common in South African water demand governance. Whilst measures such as desalination and groundwater abstraction were considered most favourable in terms of increasing available supply, whilst reducing water losses through maintenance was a secondary consideration in most cases of supply management. It was found that the re-use of wastewater in WSM was considered the most sustainable approach, however this was not commonly successful worldwide due to a poor public perception of the "yuck factor", which was over-come in various countries through effective public engagement and monitoring. In terms water governance is was found that the decentralisation of decision-making regarding water governance has not been effective in South Africa, and the role of local government in water governance is still minimal.

Social networks play a key role in the spread of views and behaviours, and the study and analysis of social networks has been shown to reveal how views and behaviours spread through a social network. It is theorised that social networks can facilitate the spread of climate change attitudes and beliefs, and influence policy and the enactment thereof. The literature found that the spread of views and behaviours in social networks is often dependent on the characteristics of social networks, such as the strength of the ties in the network and the size of the network. Both strong and weak ties were deemed to have an influencing effect on the spread of views and behaviours in a network and this was shown through work by Granovetter (1973), Grafton (2005) and Krackhardt (1994). Social networks were also shown to play an important role in natural resource governance. It was shown that social networks can be more influential than formal institutions in ensuring compliance with environmental legislation. Social networks can also facilitate collaboration between stakeholders, and thus play an important role in the management of natural resources such as water, where so many interests are vested.

3 Methodology

This chapter will provide an overview of the study area as well as the methods utilised to carry out research for this research. Thereafter the focus shifts to how data were collected and analysed, with the chapter concluding on a section covering limitations and ethical considerations for this research.

3.1 Study Area

3.1.1 Municipal focus

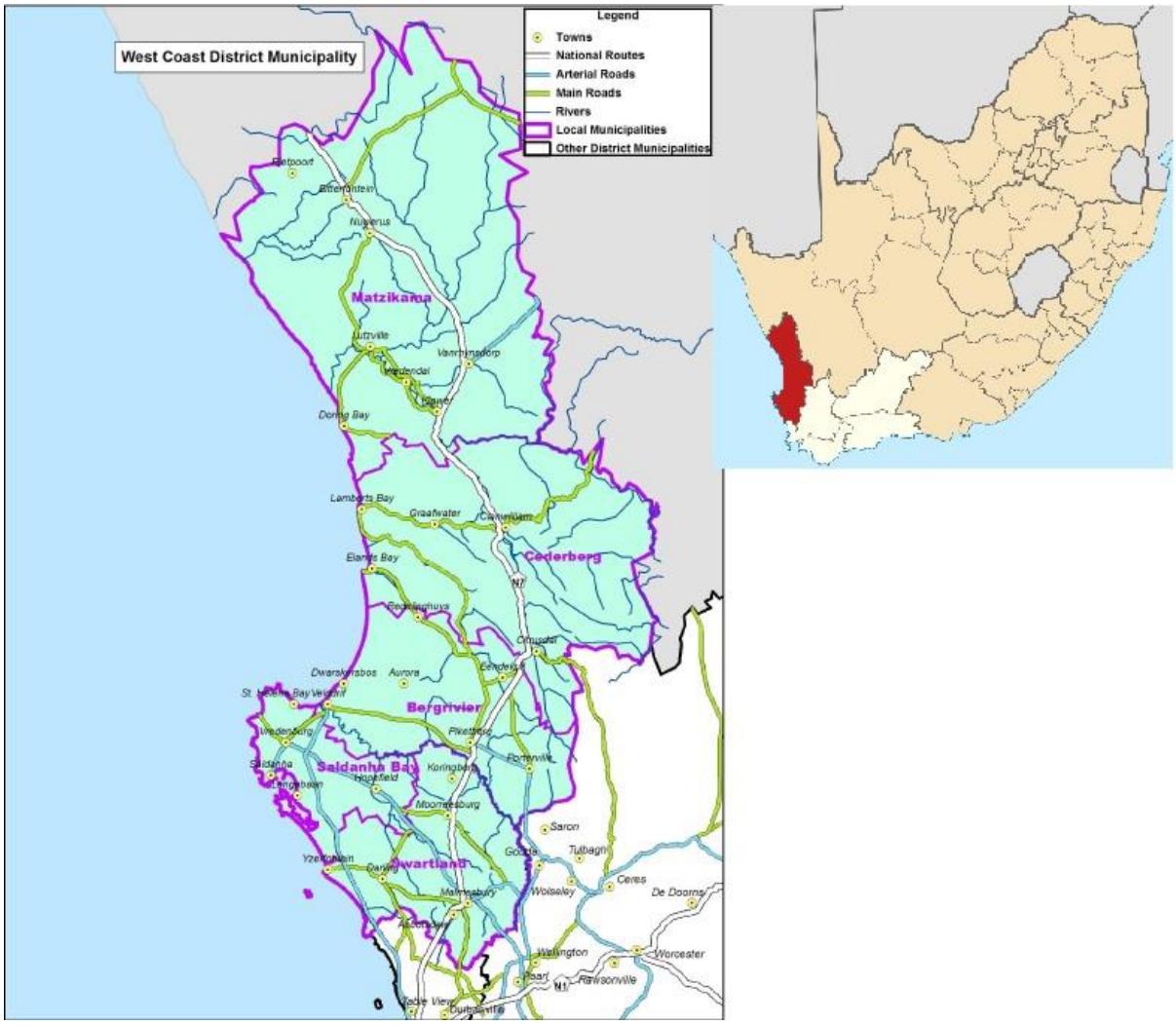

Figure 3-1: Study area - West coast district municipality showing the borders of the local class B municipalities (purple lines). The box on the upper right-hand corner shows the location of the WCDM (in red) within the western cape province of South Africa (light tan). Dark tan represents other district municipalities. (Source: West Coast District Municipality, 2019)

The study area for this research encompassed local municipalities within the West Coast District Municipality (WCDM) of the Western Cape of South Africa. The study included the following municipalities: the Bergrivier Municipality (BM), the Swartland Municipality (SM),

the Matzikama Municipality (MM), the Cederberg Municipality (CM), and the Saldanha Bay Municipality (SBM) (**Figure 3-1**). The focus of the study is on class B municipalities, which are local, non-metropolitan municipalities, which stand in contrast to district municipalities and metropolitan municipalities. A brief description of municipalities within the context of the South African legislative and executive landscape is given by Pasquini, Cowling & Ziervogel (2013). Metropolitan municipalities, namely class A, exist in the biggest cities in South Africa. Metropolitan municipalities must co-ordinate and deliver services to the whole area. District municipalities, or class C municipalities, are made up of several local municipalities that fall within one district. These are usually made up of four to six local municipalities. District municipalities are required to coordinate development for the whole district and this responsibility is to ensure that the most vulnerable people are not overlooked. Finally, local municipalities, or class B municipalities, are required to deliver services such as electricity and water to their locality and meet community needs (Pasquini, Cowling & Ziervogel, 2013; Western Cape Government, 2013a&b). In terms of water management, class B municipalities are mandated to charge fees for municipal services such as water, and in terms of the Constitution of South Africa, class B municipalities are also responsible for water supply to households, sewerage and sanitation, and stormwater systems (Western Cape Government, 2013a). District municipalities, which usually comprise of several local municipalities, have functions that involve the bulk supply of water to the local municipalities from the main, nationally- or provincially-operated, water supply network, bulk sewage purification and main sewage disposal, as well as municipal public works (Western Cape Government, 2013b).

3.1.2 Water resources and climatic projections for the west coast district

The geographical area covered by the WCDM is chosen as the regional area for this study, as it is identified as being water-stressed (West Coast District Municipality, 2014). Thus, aspects of water demand and supply management, as well as future water constraints linked to climate change are likely to be identified as being important in the municipalities. Furthermore, the WCDM relies heavily on agriculture, and it is noted that farmers stand to lose a great deal of income should their crop be ruined by drought or other climate related disasters (Partridge & Wagner, 2016). The importance of climate change and its associated constraints to water management is evident in the WCDM Integrated Development Plan (IDP) 2017-2022 (WCDM, 2017), which refers (p. 67 & 70) to a drought management plan, as well as to the impacts of climate change making drought more common in the area. It is also noted that the local municipalities include drought as a risk factor in their IDPs (Bergrivier Municipality, 2017a; Matzikama Municipality, 2012; Swartland Municipality, 2018; Cederberg Municipality, 2018; Saldanha Bay Municipality, 2018). An IDP is a high-level plan for an entire municipality and gives an overall framework for the development of the municipality. IDPs are developed for all levels of municipal government, from local right through to national. Therefore, it is important that local municipalities' IDPs are aligned with those of their District Municipality, Province, and the National Development Plan.

Within the context of climate change, climate change models for the period 2030-2045 for the Western Cape (Western Cape Climate Change Response Strategy, 2014) note six areas of concern regarding climate change. These include, specifically for the West Coast: higher mean annual temperature, higher maximum temperatures, higher minimum temperatures (fewer cold days and nights), a general drying trend in the western part of the country, intensification of rainfall events leading to more flooding and soil erosion, and increased mean sea level and associated storm surges (Western Cape Government, 2014). Impacts of direct concern to water management within the WCDM include those of increasing aridity, which will likely impact surface water supplies, such as dams, as well as increased sea-level rise, which will impact the quality of groundwater in coastal areas.

Historically, the WCDM received the bulk of its water supply from surface water sources, namely the Voelvlei Dam and Misverstand Dam, managed by the Department of Water and Sanitation (DWS), with a small amount coming from groundwater abstraction (West Coast District Municipality, 2017). This supply is then shared between the five local municipalities within the district. Several local municipalities augment this supply with other surface water sources, such as the Berg River, the Clanwillian Dam, the Olifants River, and a few small groundwater sources such as boreholes and springs (DWS, 2015). Matzikama municipality utilises a small-scale desalination plant to treat the brackish water from the town of Bitterfontein's groundwater supply (Western Cape Government, 2018). The WCDM has exceeded its allocations from the DWS for the last six years as per the Western Cape Water Supply System (WCWSS) status report (Department of Water and Sanitation, 2016), and in the face of climate change projections this suggests that the prognosis for the West Coast is high risk in terms of managing their water supply successfully.

3.2 Research design

This research utilises a mixed-methods research approach, comprising both quantitative and qualitative data collection and analysis. In the following section the rationale for this mixed-methods approach will be explored, as well as the overall case study approach utilised in this research.

3.2.1 Case study approach

This research adopts a case study approach as its overall methodological approach. A case study approach allows the researcher to gain a detailed understanding of the processes involved within the specific research setting in this case, that of water management and climate change adaptation at a local municipal level. A case study can be defined as a strategy of research which aims to understand social phenomena within a single or small number of naturally occurring settings (Bloor & Wood, 2006). As this research is exploring the nature of the views and behaviours of specific actors within local municipalities as they are shown, a case study approach makes the most sense. Furthermore, this research is looking at the effect of social network characteristics on views and behaviours, and by covering several

municipalities it is possible to compare how social networks influence water management decisions within the municipalities. It is beneficial to focus on a group of municipalities to see if any patterns exist with regards to certain social network characteristics and/or ties within the municipalities resulting in certain views and/or behaviours. I.e. does an actor within a specific municipality, who exhibits strong ties with external nodes in their network, result in similar views and/or behaviours being exhibited by an actor in another municipality exhibiting the same social network characteristics? This type of broader study helps to potentially identify the influence that social network characteristics have over views and behaviours within local municipalities. A distinctive feature of case studies, as identified by Bloor & Wood (2006), is the exploration of a bounded system, which in the case of this study is a series of municipalities within a larger district municipality.

3.2.2 Qualitative and quantitative mixed methods approach

This research made use of both quantitative and qualitative data in its analysis and therefore constitutes a mixed-methods approach. Mixed methods research is defined by Johnson and Onwuegbuzie (2004) as a type of research where the researcher combines quantitative and qualitative research techniques, methods, approached, concepts or language into a single study. Expansive data collection in mixed-methods research allows for a more thorough gathering of evidence, and thus stronger conclusions, however, the extent of the information gathering and the ability to build strong conclusions rests on the researcher and thus a researcher needs to show strong competence in a variety of research methods (Johnson and Onwuegbuzie, 2004). By utilising both quantitative and qualitative data this research was able to highlight aspects of social network characteristics, such as strength of ties, and apply them to qualitative aspects such as views and behaviours, whereby possible relations between the two (i.e. strength of ties and views) could be determined. In order to overcome the difficulty of multiple research methods, the researcher adopted simple quantitative methods, and utilised these methods to provide sustenance to the qualitative results, which are focused on more thoroughly in this research. Data for this research were gathered through an interview process. In order to gather data which were both qualitative and quantitative, a semi-structured interview was conducted, which included a section comprising close-ended questions. In order to ensure quantitative responses were received, answers were scaled appropriately as discussed in **section 3.3** on interview design.

According to Leedy & Ormrod (2010), qualitative studies typically serve one or more of the following purposes: description, interpretation, verification, and finally evaluation of a research question. Qualitative studies can reveal the nature of certain situations, settings, systems, or people. They can also enable a researcher to gain new insights about a phenomenon, develop new concepts, or discover the effects of various phenomenon. Furthermore, qualitative research can allow a researcher to test the validity of certain assumptions, claims, theories, or generalisations, within the real-world contexts. Finally, they can provide the means through which a researcher can judge the effectiveness of particular

policies, practices, and innovations. As this research aims to gain new insights into the views and behaviours of municipal actors, a qualitative approach is utilised. On the other hand, quantitative research involves identifying the characteristics of the observed phenomenon or exploring possible correlations among two or more phenomena.

Qualitative data was gathered to determine the views and behaviours of the actors with regards to water management and climate change. Quantitative data has been used to measure the strength of the ties between the actors and their social networks, as well as the nature of the ties, which has been utilised to provide support for theory that views, and behaviours can be influenced by the nature of the actors given advice network. The nature of the quantitative data gathered, and the units utilised are covered in **section 3.4.3**. According to Leedy & Ormrod (2010), semi-structured interviews are best suited for gathering the data in a qualitative study, and therefore were selected as an appropriate data collection method for the qualitative component of this study. Interviews are commonly used for gathering data such as people's beliefs, views, and perspectives, as well as feelings and motives (Leedy & Ormrod, 2010: 148; Ayres, 2012) and as such were used to gather information on the views and behaviours of municipal actors involved in water management. As the interview progresses, additional questions can be asked, and questions can change as the interview progresses. Closed-ended questions provide the respondent with specific responses to a question based on what quantitative information the interviewer is attempting to gather (Traugott, 2011; Lavrakas, 2011), and as such were used to gather data on the nature of the actors given advice network (tie strength etc.) in this thesis. According to Lavrakas (2011), closed ended interview questions must fulfil two criteria: they must be mutually exclusive, and must be exhaustive. No two options can over-lap one another in meaning, and all available options must cover all logically possible responses to the question. Thus, close ended questions were assigned values as responses, such as on a scale of 1-5 as shown in **Appendix 1**, to ensure answer exclusivity and allowing for quantitative analysis.

This research consists of exploratory research that combines the concepts of SNA and climate change adaptation. Exploratory research does not attempt to solve any practical problems, or test a hypothesis, but is rather used to make initial forays into studying new or poorly understood phenomena (Colman, 2015). The main purpose of exploratory research is to improve the researcher's knowledge of a topic; it focuses on the discovery of ideas and insights as opposed to collecting statistically significant data. In the case of this research, the final objective is to contribute towards a base of knowledge and theory in how views and behaviours are formed in the areas of climate change and water management at a local level, so that further research may delve into the specifics of what influences views and behaviours around water management and climate change adaptation, and greater detail into how these views and behaviours are formed, changed, and acted upon.

3.2.2.1 Selection of Target Study Actors

Selection of the target study actors was done through purposive sampling, which describes the selection of a sample based on a specific characteristic of the population (Crossman, 2016). The purposive sampling method is essentially a method of selection whereby the researcher deliberately seeks out participants with a particular set of characteristics, usually knowledge of the research issue, or through qualities the participants possess. Essentially, the researcher decides what information needs to be known, and sets out to find respondents who are able and willing to provide the information (Jupp, 2006; Tongco, 2007; Given, 2008). Purposive sampling is used in a variety of studies of skills, knowledge, or practice. Purposive sampling is often used in a case study approach to research and is useful in determining perceptions and views of groups around a topic (Tongco, 2007). It is imperative to best select the manner and source in which data is gathered, particularly in understanding a theoretical framework (Tgonco, 2007). Thus, the explorative nature of this study lends itself to using purposive sampling as a tool for choosing respondents. Purposive sampling is often used with qualitative research (Given, 2008). In the case of this research purposive sampling was used to determine which respondents were best positioned to provide insight into views and behaviours around water management, climate change, and climate change adaptation, at a municipal level. Thus, participants with knowledge of water management at the municipal level, knowledge on environmental/climate change issues, and a sample which varied through municipal hierarchy were ideal for this research. A sample which varied through hierarchy provided a more in-depth view of the thought process around water management and climate change within the municipality. Furthermore, a wide sample allowed for a more thorough analysis of views and behaviours throughout the municipal actors involved in water management at a given municipality. The management of water supply and demand is one of the most important aspects of adapting to the impacts of climate change on freshwater resources. Seeing as local municipalities play a key role in the supply of water to end users, their role is key in ensuring demands are met and managed.

Actors were identified through contacting the various municipalities via e-mail and phone-calls, usually from contact details obtained on the municipality's website. Initial contact was usually made with a municipal receptionist or switchboard, who would then direct the call appropriately. This process usually resulted in access to one or two individuals, who then provided further assistance and contact details of more individuals (i.e. through a snowball sampling technique, which yields a study sample through referrals via individuals who know of others who are of interest to the research (Biernacki & Waldorf, 1981)). In the case of the Berg River Municipality, access was gained through contacts at the University of Cape Town who had conducted prior work with the municipality.

The core focus for interviews was on municipal employees tasked with water management. The specific names of departments dealing with water management may vary from municipality to municipality, however, the heads of these departments were selected as study

actors, as their roles include operations such as the bulk purchasing and distribution of water (Bergrivier Municipality, 2016; Pasquini et al, 2013; Western Cape Government 2013a). Additionally, municipal managers were chosen as a study actor due to their role in the day-to-day functions of the municipality (Pasquini et al., 2013). The role of the municipal manager is to implement all programmes approved by the municipal council; thus, they will play a key role in any water-related decisions. The study also interviewed a couple of environmental officers with several municipalities. Environmental officers, whilst their roles differ from municipality to municipality, play an important role in environmental management within municipalities. These roles are given in various legislation and are often enshrined in by-laws (Middleton, Goldblatt, Jakoet, and Palmer, 2011). Environmental officers were targeted for interviews as their views and behaviours regarding water management were considered to potentially be more environmentally conscious.

3.3 Interview design and data collection

Interviewees were questioned according to four main categories. These were as follows:

1. Views and behaviours regarding water supply and demand management, climate change, and climate change adaptation;
2. Who the five main individuals / organisations they consult for information relating to water management are;
3. Common views and behaviours within their given advice network, and
4. The social network nature and characteristics of the interviewees' given advice network.

Questions within each category, as numbered above, were geared towards understanding aspects of water management, climate change, and climate change adaptation, specifically regarding views, behaviours, and norms. Refer to **Appendix 1** for the interview guideline used.

Interviews were conducted from the period January 2017 to March 2017 at the respondents' place of work. Interviews lasted between 30 minutes and one hour, on average, and were conducted in English. Interviewees were requested to sign a voluntary consent form prior to interviews commencing, a copy of which is shown in **Appendix 3**. The interviewer introduced themselves as being from the University of Cape Town's African Climate Development Initiative and was conducting research on climate change adaptation and water resources, and the influence of social networks thereon. Interviews were recorded, and then transcribed for easier analysis. Responses were categorised as per **Appendix 1** into the following components:

- Views and behaviours,
- Norms,
- Social network ties, and
- Tie strength

Copies of all raw audio files are kept by the University of Cape Town as well as copies of the transcriptions.

Details as to the nature of the data gathered in this research are discussed below in the sections on views and behaviours, and the nature and strength of ties.

In total eleven actors were interviewed across the five municipalities, with the interviewee's positions ranging from municipal managers (1 respondent) to heads of engineering/civil works (5 respondents), technicians within the engineering/civils department (3 respondents), and environmental officers (2 respondents).

3.3.1 Views, behaviours and norms

During the interviews, respondents were asked a range of questions to elicit their views, behaviours, and norms around water management, climate change, and climate change adaptation. Behaviours were questioned so as to garner the respondent's ideal behaviours, or what they would actually do in the situation. Questions focusing on views around the best way to manage water, and the best way to respond to climate change, were separated out in the interview guide as water management is often expressed as a case of meeting demand with available supply, and whilst a changing climate may have an impact on available supply, this is not always clear. Descriptive and injunctive norms around climate change and water management were determined by looking at what the actor sees as being normal behaviour within their network, and what behaviours are believed to be commonly approved of within their municipality. A comparison of municipal documents, which were obtained from the various local municipality's websites, was done in order to determine if the actor's views and behaviours were aligned with what their municipality did.

3.3.2 Nature and strength of ties

To better understand the influence of social networks on views, behaviours, and norms, actors were asked to provide the top five individuals and/or organisations from which they receive the majority of their information regarding water management and climate change. This question was followed up with questions on the nature of the connection the actor held with each of the top five ties indicated. These questions were posed to evaluate the nature and strength of social ties within the advice network of the actor.

Tie strength was determined using three criteria, following Krackhardt (1994) and as elaborated upon in **sections 3.4.2 and 3.4.3**, which were:

1. Dependency: how dependent is the actor on a particular node for information?
2. Intensity: how often do the actor and the node interact?
3. Affect: how the actor feels about the node, which is measured as a combination of the level of conflict between the actor and the node, and the level of intimacy in the relationship.

Affect, according to Krackhardt (1994) is a measure of how a person feels about another in the relationship. This is can be strong (love, hate, reverence) or mild, or indifferent (weak). As actors were questioned on the intimacy of the relationship they had with a node in their social network (i.e. colleague, or colleague and friend etc. see **Appendix 1**), it was important to determine if this relationship had any negative connotations as well, and thus conflict was measured (see **Appendix 1**). The combination of type of relationship and conflict, or lack thereof, allowed for a more accurate measurement of affect, and thus affect was measured so.

Each of the above tie-strength criteria was assigned a numerical value for the response, such as with a Likert scale (Likert, 1932). The value was assigned before the interview on a scale of 1 to 5. Tie strength is covered in greater detail in the sections on data analysis and in **Table 3-1**.

3.4 Data analysis

3.4.1 Determining views, behaviours and homophily.

Views and behaviours were categorised during the interview process into aspects of WDM, WSM, climate change, and climate change adaptation (see **Appendix 1)**. Once the interviews were transcribed, views and behaviours were coded and tabulated. By tabulating the responses of views and behaviours it was possible to discern which actors had similar views and behaviours, and which views and behaviours were most common with regards to the local municipal actors interviewed. Additionally, whether the actors and their ties reflected any homophily, i.e. a sharing of views and behaviours within their given social network, was also determined.

3.4.2 Applying a social network framework

A social network approach is used here to analyse how a particular actor, connected to a social network of nodes involved in water management, may have their views and behaviours, with regards to water management and climate change, influenced by the views and behaviours of those within their social/advice networks. Using a social network approach assists in determining how the characteristics of an actor's network may influence that actor and their views and behaviours with regards to climate change adaptation in water resource management (Kempe, Kleinberg, & Tardos, 2015)

This research is not adopting a "whole network" analysis but is rather taking the approach of an "ego network" analysis. This focuses on the network surrounding one actor (Marin & Wellman, 2014), as opposed to a whole network analysis which focuses on several actors and their connections with one another. The usage of an ego network makes the most sense for this research as the SNA aspects of the research are looking at the given advice network of the actor, and how the advice network potentially influences their views and behaviours. The nodes of the network are usually selected on chosen relations with the central actor, and on

relations between the nodes, for example who the actor interacts with on a project. In the case of this study, the ego network was bound to the people whom the central actor receives the bulk of their information on water management and climate change from, referred to in this research as the actors' "advice network". This was limited to the five nodes the central actors describe as being their key sources for information on water management and climate change.

Within the bounds of this ego network described above, relations between the actor and his/her five key nodes, i.e. their ties, were measured so as to determine in what ways they may exert influence over the actor's views and behaviours. The ties between the actor and a node within their advice network, are described as "directed ties" by Marin & Wellman (2014: 18) and are discussed in further detail in section 2.2.2 of the literature review. Within this research, the nature of these ties, i.e. their dependency, intensity, and relational aspect, was assigned a value and thus could be measured as strong or weak ties. Each component of the tie was assigned a numerical value, where the lower value equates to a characteristic, such as intensity, dependency, or affect, which is weak, and the higher value equating to a characteristic which is strong. These values were added up to determine the overall tie strength between the node to the actor. This measurement approach is discussed further in **section 3.4.3.** Once the strength of ties was determined, homophily between an actor and his/her network was determined in order to explore how the actors' given advice network may influence their given views and behaviours around water management and climate change. Homophily was determined by questioning the actor on whether they believed that their views and behaviours were shared with their given advice network (Appendix 1).

3.4.3 Strength of Ties

By adopting a similar approach to the model for network processes as described by Krackhardt (1994) and discussed further in the section 2.2.2 in the literature review and section 3.4.2 above, it is possible to determine the strength of the actor's ties. Strength of ties are measured through three relational dimensions, namely dependency, intensity, and affect, i.e. how reliant an actor is on a tie, how often they interact, and how they feel towards the tie. As shown by Krackhardt (1994), these three aspects are not mutually exclusive and need to be analysed together to determine an overall strength of tie. A strong dependency would likely foster more frequent interaction between the actor and the tie, whilst more frequent interaction may foster either positive or negative feelings about the tie. This can work both ways, with a weak dependency leading to less frequent interaction, and thus leading to either positive or negative feelings towards the tie. Thus, it is important to look at each relational dimension and how they contribute to the overall strength of the tie. For the purpose of this research, each of the criteria for tie strength was assigned a numerical value according to the response of the interviewee. For ease of analysis, the criteria of dependency and intensity are measured on a scale of 1-5, whilst affect is measured on a scale of 1-10, with two sub-criteria,

namely intimacy and lack of conflict, being measured on a scale of 1 to 5 (as explained above in **section 3.3.2**). These scorings are represented in **Table 3-1**.

Table 3-1: Numerical values for each category in determining the strength of ties for the various actors. Based on Krackhardt (1994)

	Dependency (1-5)	**Intensity (1-5)**	**Affect (1-10; measured as intimacy + lack of conflict)**	
Value	Reliance	Frequency of interaction	Intimacy (1-5)	Lack of Conflict (1-5)
1	Rarely rely on for information/never seeks	Rare	Purely professional	Full conflict/never agreeing
2	Rarely seeks information/not reliant	6 months	Friendly colleagues	Mainly conflicting views/behaviours, but sometimes agreement
3	Reliant on and occasionally seeks information	Quarterly	Interact outside of the workspace on non-work-related grounds	Views and behaviours sometimes conflict, but agree most of the time
4	Reliant on and seeks information regularly	Monthly / Fortnightly	Considered friends and will interact regularly outside the bounds of professionalism	Views and behaviours rarely conflict and almost always in agreement
5	Very reliant/always seeking information	Weekly / Daily	Close friends/intimate relationship	Full agreement

Dependency, as per Krackhardt (1994), is determined as the perceived reliance the actor has on their tie, as shown in **Table 3-1.** Similarly, intensity is measured as how frequently the actor and tie interact. Finally, affect is measured by determining the level of intimacy between the actor and the tie and summing it with level of agreement between the actor and the tie. A high affect is determined where there is a strong intimacy between the actor and the tie and where the relationship has little to no conflict. A weak affect on the other hand, is where the

relationship between the actor and tie is purely a professional one involving their work together and has high levels of conflict.

Using the values assigned in **Table 3-1**, the following scales (**Figure 3-2** and **Figure 3-3**) are used to represent tie-strength per category. This approach is based on Krackhardt's (1994) work on the strength of ties. The values 1 to 5 correspond to the interview questions as show in **Appendix 1.**

20%	40%	60%	80%	100%
1	2	3	4	5
Weak		Average	Strong	Very strong

Figure 3-2: Tie strength for the categories Dependency and Intensity. Percentages are given for representative purposes and are referred to in the results and discussions.

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	2	3	4	5	6	7	8	9	10
Weak				Average		Strong		Very strong	

Figure 3-3: Tie strength for the category Affect which involves the summation of two sub-categories, Intimacy and Conflict. Percentages are given for representative purposes and are referred to in the results and discussions.

Furthermore, using the values in **Table 3-1** for each sub-category, the following formula was adopted to determine overall tie strength. Values are based on the interview responses, as discussed above, and the overall tie strength utilises a simple summation of the relational dimensions, as given by Krackhardt (1994).

$$Tie\ Strength = Reliance + Frequency\ of\ interaction + intimacy + lack\ of\ conflict$$

Using the formula above, the highest possible value for the strength of a tie would be 20, and the lowest would be 5 (displayed in **Figure 3-4)**.

25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Weak				Average				Strong				Very strong			

Figure 3-4: Scale showing the strength of ties with 5 being the weakest possible value, and 20 being the strongest. Percentages are given for representative purposes and are referred to in the results and discussions.

3.5 Limitations

Purposive sampling, as used in this research, has its own sets of drawbacks and limitations. Tongco (2007) states that a danger with purposive sampling is that the researcher exercises judgement on the informant's reliability and competency. In this case, judgment was mitigated by ensuring that those interviewed fulfilled a role in the municipality relating to water management or environmental services and thus reliable and competent informants were identified for the interviews. Furthermore, the researcher must be alert for possible biases from the interviewee. This leads to the issue of social desirability bias.

Social desirability bias, social bias, desirability bias, or response bias, is what occurs in interviews when a respondent chooses to respond to questions as "good" people "should", or in a socially acceptable manner. This is done by respondents to project favourable images of themselves (Vogt, 2011; Spector, 2011; Callegaro, 2011). This bias occurs mainly in questions that deal with personally or socially sensitive content. It is often an indication of an individual's need for approval that results in these skewed responses (Spector, 2011). In the case of this study, it is possible that respondents might have shared views or beliefs that they believe are more acceptable in the context of climate science and adaptation.

There are several ways to deal with social desirability bias. One such technique deals with the way the interviewer words their questions (Callegaro, 2011). Spector (2011) deals with two other methods, which focus on designing methods to reduce the impact of social desirability bias, such as scale items, which are not related to desirability, placed within the questions, or eliminating individuals from analysis who score highly on a set of dummy questions dealing with social desirability bias. With regards to this study, the interviewer made sure that the interviewee felt comfortable with the nature of questions. The interviewer made it clear that there was no "right" or "wrong" answer, and to assist with these questions, they were started with phrases such as "in your own view" or "what would you do in this situation". It was also addressed in the ethical considerations of this research – which were made clear to respondents - that the interviewees would not be identifiable through their responses, and this was thought likely to assist in helping respondents be open in their views and behaviours. The interviewer also ensured that he presented himself in as neutral a manner as possible, which was achieved by not entering the interview with large amounts of paraphernalia and intimidating equipment, and ensured that just the basics for recording and making notes were brought in.

A further limitation to this study is how homophily was determined. During the interview process the sharing of views and norms between the actor and their given advice network was determined by the actors themselves. This limits the findings of the study as it is not an independent measure of the views and norms of the node, but an assessment of opinion.

In certain municipalities, due to various constraints on the municipal side, as well as with the time available for the researcher, only two actors were interviewed rather than the preferred

three to five actors. However, the study was exploratory in nature, and as such was looking to show how views and behaviours are formed in the areas of climate change and water management, and not provide statistical generalisability of the findings or to provide conclusive evidence for the formation of views and behaviours.

3.6 Ethical considerations

Ethical aspects of this study included the consideration of anonymity and confidentiality of the interviewees. The anonymity and confidentially has been ensured by not referring to the interviewee's name, or job description, within the research. Furthermore, analysis was not performed on the role each individual played in decision making, but more on how the norms and views they hold on climate change may be influenced by social network characteristics. Thus, the incorporation of identity was not necessary for the study and was completely avoided. This research followed ethical procedures as laid down by the University of Cape Town Science Faculty Research Ethics Committee, shown in **Appendix 2**.

4 Municipal actors' views and behaviours on water management and climate change

As discussed in Chapter 2, in **section 2.2.2** on **Views, behaviours and norms, and their spread through networks**, it was noted that the difference between views and behaviours can be shown as 1) how one sees the world and how one should deal in response to it with it (views), and 2) what one would do in response to an event or situation (behaviours) (Porta, 2014; Gray, 1985). In this chapter the various actors' views and behaviours regarding aspects of Water Demand Management (WDM), Water Supply Management (WSM), climate change, and climate change adaptation are examined. WSM and WDM are separated in the presentation of the findings of this research for ease of discussion and to highlight favoured processes and procedures. However, in principle measures of WSM and WDM are both considered by actors in terms of water management and are not intended to be represented as either/or options. Views and behaviours of WSM and WDM are important to ascertain because the West Coast District Municipality (WCDM) in the West Coast of South Africa is a water-stressed area, and because local governments have an important role to play in water management, thus their views and behaviours around water supply and demand will be important in the context of the future resilience of the area's water resources to climate change. These views and behaviours will be related back to the historic and current approaches to water management and climate change adaptation. The research will then discuss how the views and behaviours expressed by the actors are dealing, or not dealing, with water management challenges and climate change.

4.1 Water demand management

The most common response expressed by respondents regarding their view on how best to manage water demand, i.e. how to most effectively manage water demand in their municipality, was that of raising awareness and education around water scarcity (*n* = 9). It must be noted that respondents also favoured other options in conjunction with this, and thus did not provide just one option. Respondents also favoured the introduction of water restrictions (*n* = 7), whilst other views to reduce consumption consisted of incentivising the saving of water, re-using grey water, and better maintenance of existing infrastructure to reduce leaks (each *n* = 1). The low scoring for leak reduction is potentially related to the low non-revenue water, which is water that is unbilled, or lost, before it reaches the consumer, which is relatively low in the WCDM (less than 18%) compared to the national average of 40% (Green Cape, 2018). This water loss is usually through leaks in the water supply system, or other faulty infrastructure (Hedden, 2016). The conjunctive responses relate to what was said in **section 2.1.4.1** whereby WDM measures are most effective when run together. Most respondents did not make it clear as to which option was their preferred option when stating their views on WDM. The effectiveness of demand management measures is discussed

further below as well as the issues around longevity and effectiveness, as raised in **section 2.1.4.1**.

With regards to the value of education for reducing water consumption, which was the most popular view, the following quote provides an illustration of respondents' views in this regard.

> "*… people do not realise the amount of water that they are actually wasting, because they are not educated*" (Respondent MM1, Matzikama Municipality)

The quote illustrates how the respondent views education as the key to limiting wastage of water, and thus reducing consumption. It is this respondent's impression that with education and awareness on the topic of water, water wastage, and thus consumption, would decrease.

Only two respondents made no mention of awareness and/or education as being the most effective method of reducing consumption. These respondents both viewed fiscal measures (i.e. increasing water tariffs or incentivised saving of water) as being the most effective. This view of favouring awareness and education campaigns, as well as water restrictions and fiscal measures for WDM, relates to what was discussed by Rabe et al. (2012) and Jones (2018), as discussed in **section 2.1.4.1,** who show the effectiveness of running water education campaigns in conjunction with water restrictions. Rabe et al. (2012) and Jones (2018) both highlight the effectiveness of combining education campaigns, to create a long-term conservation state of mind, whilst water-restrictions enforce quick successful reduction of water use. As the results show for the two cases described above (the City of Cape Town case and the Knysna Municipality case) in the literature review on **Demand and supply management** in South Africa (**section 2.1.4.1**), the implementation of awareness and education campaigns can yield good results for WDM. Actors who viewed raising awareness as key to WDM often spoke of how a change in mind-set was tantamount to reducing consumption, and as stated by a respondent within the Swartland Municipality, the mind-set of "not caring" needs to be addressed, and this can only be addressed through education (Respondent SM2, Swartland Municipality)**.**

In terms of the actors' actual behavioural response, the most frequent behavioural response to managing water demand was the introduction of water restrictions (n = 7). This differs from the actors' views on how best to manage water demand, where raising awareness was viewed as being the most frequently mentioned way of managing water demand. Raising awareness was only mentioned by five actors when questioned on their municipality's behaviours, which is in contrast to the nine actors who viewed it as being the most effective way of managing demand.

A possible reason for the difference in views and behaviours expressed by the respondents is that the actors' views around WDM may be what is seen as an ideal long-term solution, whilst the behaviours given are what are considered more effective short-term solutions. Russel and Fielding (2010) argue that water conservation behaviours can be influenced by five underlying

causes, namely: attitudes to WDM, beliefs around WDM, the actor's habits, the actor's capabilities, and the context in which the actor is in. Thus, varying attitudes and beliefs, as well as capabilities of the respondents may be the cause for the varied views and behaviours on WDM. However, awareness campaigns were a consistent theme across both views and behaviour. Syme et al. (2000) states that awareness campaigns can be used on a long-term basis to maintain a conservation state-of-mind surrounding water use. However, they need to be continually maintained and this can become costly to the municipality if the water savings are not sufficient. Furthermore, as mentioned previously, it is often difficult to measure the effectiveness of awareness campaigns (the most popular view expressed), and thus WDM options which are easier to quantify, and implement are likely favoured, such as water restrictions, in times of drought and water constraints. However, contrary to Syme et al. (2000), Inman and Jeffrey (2006) note that the effect of awareness campaigns is often short-lived, and the effectiveness of them is often difficult to maintain. However, evidence of the rapid and successful effect of awareness campaigns has been shown in the discussion around the Knysna Municipality (Rabe et al, 2012) and the City of Cape Town (Jones, 2018; Winter, 2018) in the literature review. A further point raised by the actor BM 1 was that municipalities have the ability to enforce measures such as water restrictions more easily, through legislative measures, rather than awareness campaigns. These measures are mentioned in by-laws such as the By-Law relating to water supply, sanitation services and industrial effluent (Bergrivier Municipality, Western Cape Provincial Gazette 6675, 2009).

Respondents mentioning a variety of views and behaviours on WDM relates back to what was discussed in section 2.1.4.1, in that a conjunctive approach to WDM measures provides the most effective outcomes when managing water supply. It is proposed that actors apply these measures appropriately and not put all their eggs into one basket when relying on WDM measures. Actors could place more effort in ensuring the continuity of a conservation state of mind with water users, as this will likely assist in mitigating any water shortage emergencies.

4.2 Water supply management

When questioned on how best to increase the supply of their municipality's water supply system, two broad categories of views were expressed by respondents, these being: the management of existing supply, and increasing available supply. Responses were evenly split between the two categories, with some actors outright favouring increasing supply (*n* = 4), some the management of existing supply (*n* = 3), and other actors (*n* = 4) mentioning both. Maintenance of infrastructure and improving current water management practices (*n* = 4 each), under the category of management of existing supply, and utilising alternative sources of water, namely groundwater (*n* = 4) under the category of increasing available supply, were the most popular views on WSM. Whilst all respondents (*n* = 11) mentioned ways to increase available supply, only eight (*n* = 8) respondents mentioned management of existing supply as a view to increase their municipality's water supply. Full results are tabled below in **Table 4-1**.

Most respondents expressed more than one view, thus the number of responses in **Table 4-1** are greater than the number of respondents.

Table 4-1 All responses for views on WSM, as given by respondents.

View	Method	No. of actors
Management of existing supply	*Improve maintenance of existing infrastructure**	4
	*Improve management of water supply***	4
Increase available supply	*Utilisation of groundwater sources (boreholes / well-points)*	4
	Make use of alternative sources of water (not specified)	3
	Desalination	2
	Water re-use/recycling	2
	Increase reservoir size	1
	Remove siltation build-up from dams	1

**Whilst not specified, this included better leak detection, pipe repairs, and improving efficiency of systems.*

*** Integrating management between municipalities better/better support from district and provincial government.*

The respondents who favour increasing water supply over the management of existing water supply could be doing so as a response to the status of the water supply system within their municipality, as reported in the study done by the Department of Water and Sanitation (DWS) (2015). The DWS (2015) study shows that water supply is constrained across the WCDM. The study further notes that certain towns are already experiencing shortfalls in water supply, with others approaching potential shortfalls in years to come (DWS, 2015). Thus, it would be logical that municipal officials would be concerned over the current yield of water available and would wish to increase their available yield. For example, the Bergrivier municipality, as reported by the DWS (2015), is expected to reach a shortfall in its water supply by, or before, the year 2020. The knowledge of this future shortfall is possibly an explanation for this municipality's favouring of increasing supply over the management and improved distribution of the current supply. While the Cederberg municipality is only expected to reach a shortfall around about ten years later than the Bergrivier, respondents from this municipality still favoured increasing supply over the improved management and maintenance of their existing supply.

Under the view of increasing available supply, groundwater was the most popular choice (*n* = 4), whilst desalination and water re-use/recycling were second most popular (*n* = 2 for each option). Groundwater and desalination have both often been deemed unsustainable, either financially, or environmentally (Dolnicar and Schafer, 2006 Custodio, 2000; European Environmental Agency, 2007; Eamus & Froend, 2006; Llama & Martines-Santos, 2005). However, as expressed by Riemann, Chimboza and Fubesi (2012), and Hedden (2016), groundwater is overlooked in the South African context, and if managed correctly by ensuring that issues of over-abstraction can be avoided, can be a renewable source of water. Desalination on the other hand, whilst having access to essentially an unlimited amount of water, without impacting any freshwater ecosystems, has drawbacks in terms of energy efficiency and costs, and as a result releases roughly three times the amount of $C0_2$ generated in the treatment of river or groundwater sources (Amberger, 2011). The high energy usage of desalination means that desalination is not always a cost-effective water supply augmentation option (Fritzman et al., 2007). Fritzman et al. (2007) also highlight the various environmental impacts associated with desalination, such as the discharge of brine which can impact marine ecosystems, large amounts of noise and energy usage, as well as the disposal of used membranes, which result in reduced public acceptance. In countries where the cost of energy is high, and the energy system is based on non-renewable sources, the cost to the environment, as well as the cost of running the desalination plants make them undesirable. In the case of waste-water reuse, the main concern over the use of this approach has been poor public acceptance, as noted by Fielding et al. (2018), Hurlimann & Dolnicar (2010), Ulmann & Head (2011), and Aitken et al. (2014). However, this is not insurmountable as shown by the successful implementation of wastewater reuse for potable purposes in Windhoek, Namibia, and Beaufort West in South Africa.

None of the municipalities, other than Swartland, have any form of treating wastewater beyond standards suitable for discharge into the ocean or into surface water systems. The Swartland Municipality uses the Malmesbury wastewater treatment works to treat the town's effluent to levels which satisfy European bathwater standards (Tancot, 2014), which is above and beyond permit requirements imposed by the DWS. This water, according to the respondent SM 1, is currently not used for anything and is discharged into rivers to flow to the sea. As shown in work by Fielding et al. (2018), Hurlimann & Dolnicar (2010), Ulmann & Head (2011) and Aitken et al. (2014), and as already mentioned, there is a definitive issue around public acceptance of these projects, and as Hurlimann & Dolnicar (2010) pointed out, this applies to both direct and indirect schemes of waste-water reuse, as discussed previously in **section 2.1.4.1**. To reiterate, a direct scheme would refer to treatment of wastewater, and re-injection back into the main water supply system, whilst an indirect scheme is one where wastewater is treated to a slightly lesser extent, and utilised to artificially recharge an aquifer, or is blended with other natural water resources before being re-treated for potable use and circulated back into the main water supply system, as defined by Ambulkar & Nathanson, 2019. Thus, the generally negative public opinions surrounding waste-water recycling could

be why it is not as popular a view among respondents as groundwater, or as acceptable as desalination, even though a direct, or indirect scheme of waste-water reuse is arguably the most sensible option in a water-stressed area such as the WCDM. However, as stated by Matthews (2015) in **section 2.1.4.1**, successful implementation of a waste to potable use strategy can be achieved through transparency in reporting, and proper monitoring and management.

Two respondents explicitly voiced their concerns over sustainability of the various options being explored by their municipalities. Both respondents were environmental officers. Options such as desalination and utilising groundwater were expressed as unsustainable, with the by-products of desalination, namely brine, and the intensive energy requirements and costs, being labelled as key drawbacks for this supply measure. Groundwater was deemed as unsustainable due to a lack of understanding on the impacts of groundwater abstraction on surface water bodies, determining sustainable abstraction rates, as well as impacts on terrestrial ecology. However, no concerns about sustainability were raised around water re-use by these two respondents. It is interesting to note that both these actors, while aware of the drawbacks of groundwater and desalination, yet still preferred to utilise them. This could be as these options are able to realistically deal with water supply concerns for their municipality in the short to mid-term. Furthermore, many towns within the WCDM utilise groundwater as a water resource (DWS, 2015), and thus these actors would have been exposed to this view that groundwater is a suitable option for their municipality. Additionally, the usage of desalination for towns along the coast of the WCDM has become more feasible, as is represented by the desalination plant in Lamberts Bay (Veolia, 2015), where groundwater supply could not be expanded upon, and surface water supply proved too difficult with the distance of the town from the nearest large-scale dam. Additionally, the town of Bitterfontein within the Matzikama municipality utilises a desalination plant to treat the towns brackish groundwater supply (DWS, 2015; Western Cape Government, 2018). The brackish nature of the groundwater supply is due to the underlying geology being rich in minerals. Furthermore, private industries in the WCDM are also looking to desalination to meet their water needs, such as the Luck Star fishmeal factory in St Helena Bay, which utilises desalination to meet its high-water demand processes (Burger, 2018). The finding that only two respondents discussed concerns around the sustainability of the preferred options for increasing water supply, as well as the fact that many towns are already using groundwater as well as moving towards increasing use of desalination, suggests that the municipalities within the WCDM may not be thinking sustainably about their water supply, and that more may need to be done to ensure that a resilient and sustainable water supply system can be achieved.

In terms of management of existing supply, four (n = 4) respondents indicated that they would improve maintenance of their existing infrastructure as a way to improve supply to their municipality, whilst four (n = 4) indicated that they would like to see better management of the existing supply between local municipalities, district and provincial government.

Respondents from the Matzikama municipality believed that integrating water supply management across the municipalities would be most beneficial, as this took strain off cash strapped municipalities to fend for themselves. Reference was made to the sharing of water from the Clanwilliam dam, located within the Cederberg Municipality. A respondent from the Bergrivier Municipality mentioned that he/she believed there was sufficient water in South Africa, and more specifically the Western Cape to meet demand, yet blamed poor management as a result for demand not being met. An aspect of this poor management is that of the previously mentioned non-revenue water, which is water loss through leakages and faulty infrastructure. Thus, there is clearly an opportunity to increase supply by simply maintaining and managing water losses better. However, in the Bergrivier municipality, and across the study area as a whole, actors favoured increasing supply over the better management of the available supply, and this could be due to the Bergrivier municipality having relatively low (10.9%) water losses for the year of 2017 (Begrivier, 2017b), and thus maintenance and management are not key concerns.

When comparing behaviours (ideal behaviours) with views on WSM, is it immediately apparent that management becomes a far less favourable option (*n* = 3), with increasing of supply clearly being the preferred behaviour (*n* = 6). The remaining respondents (*n* = 3) referred to both management and supply. The phrasing of the questioning for behaviours could largely be a reason for this, as when questioning actors on their behaviours, a scenario of a drought situation was painted. In order to explore preferred behaviours, actors were requested to state how they would handle a water-stressed situation, and how they would best manage their municipalities' water supply. Therefore, it is possible that when faced with an urgent water supply issue, alleviating a strained supply system would be key, thus actors would favour behaviours of increasing supply. However, increasing water supply is not always a simple process, and there is the need to legalise water use and secure water rights, when sourcing additional water sources. The process of securing a Water Use Licence (WUL) from the DWS, which is required to secure additional sources of water supply, particularly the large amounts required to sustain populations of towns and cities, has often been described as onerous, sometimes taking up to five years to secure authorisations (Naidoo, 2017). However, changes to the application process via new regulations under the National Water Act (Act 36 of 1998), promise to speed up the process and ensure Water Use Licence Applications (WULA) will receive authorisations within 300 calendar days.

Whilst respondents did not mention expansion of surface water storage or increased abstraction of surface water, implying its instability and non-sustainable supply, most actors still favoured options of groundwater and desalination, which both have environmental and sustainable concerns. Concerns over the sustainability and environmental implications of groundwater and deslination were voiced by several actors, however the embeddedness of groundwater use, and the recent uptake of desalination seem to embed these as preferred options to increase supply. Water re-use, arguably the most sustainable option was not deemed as popular, and this could be due to the negative public perception and "yuck" factor.

Several respondents did state that they would repair and improve existing infrastructure, thereby reducing losses and improving water supply, at no additional impact to the environment and less cost than augmenting the existing supply.

4.3 Climate change

Most actors (*n* = 10) understood climate change as having an impact on the hydrological cycle, which is in line with what Kundzewicz et al. (2008) and the Intergovernmental Panel on Climate Change (IPCC, 2013) state regarding climate change and water. Their focus on the hydrological cycle could be attributed to the nature of the interview being on water management, however it is likely to also constitute a representation of their area of expertise, being individuals involved in the management of municipal water. Most actors understood the impacts of climate change on the hydrological cycle as meaning changing weather patterns, changing of seasonal rainfall, and less frequent, but more intensive storms. Furthermore, most of the respondents believed that warmer summers and warmer weather would come as a result of changes to the climate. The below quote from respondent SM 1 in the Swartland Municipality displays how the respondent has noticed changes to rainfall intensity over the twenty years he/she has worked at the municipality. The quote is illustrative of the above finding that the majority of actors believe climate change is having an impact on the hydrological cycle, and that climate change is, in fact, occurring.

"Things are changing. If we look at the rainfall intensity, I've been here now for 20, 21 years, and even in this time you can see that the rainfall patterns have changed" (Respondent SM 1, Swartland Municipality)

Some respondents went further with their description on how climate change will affect them, with one actor stating that climate change will bring about increased natural disasters related to extreme weather events, and another actor stating that climate change is being speeded up by anthropogenic influence. Only one respondent stated that they were sceptical of climate change and its impacts and/or existence. This respondent stated that the science around climate change was not concrete enough, and the evidence was too easily debunked. However, the respondent did state that he believed that certain aspects of climate change are valid.

When questioned on why respondents perceived climate change as they did, two (*n* = 2) respondents referenced their own physical experiences of climate change. These experiences included longer, hotter summers, and wearing "less clothes" as one respondent jokingly stated. For example, the respondent BM 2 made note of how they experience climate change, and stated:

"We feel it (climate change) on our bodies every-day" (Respondent BM 2, Bergrivier Municipality).

This respondent went on further to explain how the municipality was opening their public swimming pools later in the year, due to the colder weather arriving later in the year and lasting for shorter periods. The respondent noted this was a gradual and slow change, occurring over twenty years. Yet to the respondent, this was a clear sign of a changing climate, and reflects a lived experience. Very few of the respondents interviewed referred to education or a knowledge base on which they based their perceptions, or an academic institution. Exceptions consisted of respondents from the Bergivier Municipality, who referred to the University of Cape Town's African Climate Development Initiative (ACDI) with whom the municipality works on projects such as the SmartAgri project, which facilitates climate change information for local municipalities and their agricultural sectors.

Based on the perceptions gathered by respondents on climate change, it is apparent that they had a good understanding of climate change, and of the projected impacts it will have on their water supply system. Most respondents did not state where they obtained their climate change information, with a few mentioning academic institutions or private sector consultancies. However, they key message here is that actors understood and saw climate change as having an impact on their water supply system.

4.3.1 The impact of climate change on water management

Actors were mostly consistent with their views regarding the role they felt climate change played in water management within their municipality. As noted above in **section 4.3**, most actors believed climate change would cause changes to the hydrological cycle through less frequent, more intense rainfall. Thus, the most common view of the impact of climate change (n = 8) was that climate change would have a negative impact on surface water supplies through a decrease in rainfall, on which most West Coast municipalities are reliant. Further views expressed (n = 3) were that increased evapotranspiration as a result of climate change would impact surface water supplies, which relates to the literature discussed by De Wit & Stankiewicz (2006), Wang et al. (2016) and Kusangaya et al. (2013). The changes in the hydrological cycle will require a change in mindset on how municipal actors protect and manage their water resources, which is discussed in more detail in **section 4.4**. A respondent from the Cederberg Municipality stated the following:

"now our minds are being forced to change to accommodate the climate change that's bringing challenges and forcing us to look at different ways to do it; how we are doing it, how are we managing the natural resources." (Respondent CM 2, Cederberg Municipality)

One respondent from the Swartland Municipality referred to the design of stormwater infrastructure, in which he spoke about infrastructure being designed to handle certain flood events and how they are expected to "fail" every five or ten years as a result of an extreme event. The actor noted that the stormwater system was failing more regularly, and this failure could not be attributed to anything other than more frequent intensive rainstorms events in his/her eyes. Although these failures could be related to poor maintenance of stormwater

infrastructure and hardening of surfaces through urbanisation. The respondent also mentioned that whilst more intense rainfall events were occurring, the frequency of general rainfall events was decreasing. An actor in the Bergrivier municipality mentioned similar concerns with the stormwater system failing to handle the infrequent, yet more intense rainfall events, around the town of Piketberg.

"Like the stormwater: if you live next to a mountain like Piketberg where the water runs at the speed of lightning and so many changes came – we have flooding that we never had before – so we budgeted for and we changed the whole stormwater. That's the best example of how climate change affected us." (Respondent BM 1, Bergrivier Municipality)

The perceived changes in the hydrological cycle that the respondents expressed will have implications for future water management and resilience development. These implications were expressed by several respondents who referred to the futility in building, or expanding on, surface water storage infrastructure, as rainfall was no longer perceived as a reliable source of recharge for these systems. This relates to the views and behaviours discussed in **section 4.2**, in which the most popular views were all focused away from surface water sources, and focusing on sources such as groundwater, desalination, and wastewater treatment and reuse. The following quote from a respondent in the Swartland Municipality refers to this futility:

If there's water in the dam we've got water and, if there's no water coming then there's nothing you can do. It doesn't even help you to build bigger dams or higher the walls and stuff like that. If there's really no water [to fill them]. *(Respondent SM 2, Swartland Municipality)*

Related to the above quote, the actors MM1 and MM2 of the Matzikama Municipality made specific reference to the expected increasing negative impacts of evapotranspiration as they receive almost all their water via an open canal running from the Clanwilliam dam to the town of Vredendal. The following quote was taken from the interview with them:

"*Obviously it's getting warmer every year and it means that your evaporation is higher so obviously if you're looking at our dams or the canal, the water's open so more water will be lost in that and also some of our piping systems are open so there will be a lot more water that you're going to lose there. So, I think we need to put some plans in place, or we need to work on a strategy in terms of how to counter that effect going forward especially the evaporation side" (Respondent MM 1, Matzikama Municipality)*

One can see that the municipality of Matzikama is aware of where their water supply is vulnerable to climate change, specifically from the impact of evapotranspiration on their open water sources. The impact on water demand will require balanced water resources management, such as a conjunctive use approach, in order to continue meeting demand. A conjunctive use approach, such as utilising surface water and groundwater to achieve

objectives of supply and maintaining ecological values has been shown as being sustainable. Furthermore, a conjunctive use approach results in less infrastructural development as it does not require the municipality to move completely away from surface water resources. Rather utilising them when the surface water resources are available, and allowing resources to recharge and vice versa (Rao, Bhallamudi, Thandaveswara, Mishra, 2004; Pulido-Velazqeuz, Andreu, Sahuquillo, 2006).

Whilst all respondents linked climate change with impacts on surface water supplies, none made direct links to the impacts of climate change on groundwater. This is of interest, as groundwater development was one of the most common responses to expanding the available supply of water. This lack of knowledge between the effects of climate change and groundwater could be related to a general lack of understanding around the impacts of climate change, coupled with human activities, on groundwater (Green et al., 2010). It is difficult to understand the impacts of climate change on groundwater, as climate change may affect hydrogeological process and groundwater sources both directly and indirectly (Green et al., 2010). This would mean that before municipalities begin groundwater development as a water resilience method, proper long-term studies should be undertaken to gauge the recharge of groundwater systems, as well as obtain baseline readings for groundwater levels and quality. It is in this regard that a water supply intervention such as water re-use could be most useful for a groundwater intervention scheme, as in an indirect re-use scheme, as it is considered more sustainable than groundwater abstraction alone and less likely to be impacted by climate change (Hurlimann & Dolnicar, 2010). However, the "yuck" factor of water re-use and the associate issues of perception could be a hindrance to its implementation.

4.4 Adapting water resources and management to climate change

The following section will focus on how municipal actors perceive climate change adaptation, and how they believe adaptation can be used to alleviate the impacts of climate change on their water supply systems. The research will also look at what municipalities are currently doing to adapt their water supply system to climate change, by analysing municipal Integrated Development Plans (IDPs) and comparing the findings to what the interview respondents had to say regarding their municipality's approach to climate change adaptation. Finally, an analysis of what is being done and how the views and the behaviours of the respondents relate to this will be discussed in **section 4.4.3.**

4.4.1 Actors' understanding and application of adaptation approaches to water management

All actors interviewed understood climate change adaptation as a response to a change within a system, which mirrors the definition of adaptation within the IPCC's Fourth Assessment Report (IPCC, 2007), with the definition provided in **section 2.1.2** of the literature review of this research. However, three respondents, two from the Swartland municipality and one

from the Matzikama municipality stated that adaptation was not considered in their municipal planning for water management, whilst the remaining respondents did make mention to it being considered within their municipality's water management planning approaches.

Actors from the Bergrivier Municipality stated that adaptation can be used to alleviate the impacts of climate change, whilst actors from the Cederburg and Saldanha municipalities believed that adaptation was useful as a tool for sustainability, i.e. for exploring more sustainable sources of water supply. Actors from the Matzikama Municipality, whilst aware of the impacts of climate change on water resources and understanding the benefits of climate change adaptation for their municipal water management, did not seem focused on adapting their water supply to accommodate for climate change. As noted above, both respondents from Swartland municipality stated that adaptation was not considered in their municipalities planning.

According to the respondents, very few of the municipalities actively engaged in climate change adaptation programmes for their water supply system, however many municipalities do include it in their planning. Whilst respondent BM 1 from the Bergrivier municipality made note of efforts being made to clear the Berg River of alien invasive species, thus improving the flow of the river and the amount of water that can be taken from it, and assisting farmers in obtaining more water from the river, none of the other respondents from other municipalities made mention of any active adaptation schemes to improve their municipality's water supply in the face of climate change. Furthermore, active measures have been put in place to alleviate the problems of flooding in Piketberg (a town in the Bergrivier Municipality), which have increased over the years, and the respondent BM 1 believes climate change is to blame. The quote below displays the changes made to the stormwater system:

"Most of our streets come directly from the mountain vertically, and in the past, we had small little drains like normal. So now what they did is they built it out and they made it like that (larger) – so now the water runs in freely. Then at the bottom towards the flat areas they changed the whole system." (Respondent BM 1, Bergrivier Municipality)

What this quote is showing, is that in previous years the stormwater system, as originally built, was able to cope with run-off from the mountain during rainstorms. However, in recent years, the stormwater system has failed, resulting in flooding in the low-lying areas of the town. Thus, the stormwater system was upgraded. However, none of the stormwater is captured for municipal water supply use. Many actors believed in capturing stormwater to increase water supply as an adaptation measure, but none of the municipal officials interviewed stated that their municipality had such a system in place or plans to implement a system.

A respondent from the Saldanha Bay Municipality stated that whilst adaptation is considered in their municipality's planning, it is usually in the form of more technocentric ideas, such as desalination and increasing storage capacity as favoured options. The actor believed that

ideas involving artificial groundwater recharge, such as in the case study mentioned by Hurlimann & Dolnicar (2010) in **section 2.1.4.1**, or as is done in the town of Atlantis in the Western Cape (Department of Water Affairs, 2010), whereby treated effluent or stormwater is used to artificially recharge groundwater to match abstraction rates. The actor believed this would be a far more beneficial approach to adapt to water scarcity and believed that these options are more sustainable.

Within the Matzikama municipality, respondents stated that whilst adaptation was understood, it was not implemented in their municipal water planning or policies. However, the respondents did state that due to the nature and age of their infrastructure they were focusing more on maintenance and management, and not adapting their water supply in other areas, which relates to what was said in **section 4.2**, with certain municipalities focusing on maintenance and management to prevent leakage and thus ensure sufficient supply to their populations. Thus, creating a resilient water supply in the face of climate change appears to not be an urgent need for the municipality, as they can save water, and increase supply to end users, by simply managing and maintaining their existing supply better.

This lack of urgency towards climate change in Matzikama is covered in further detail in **section 4.4.2**, where climate change adaptation planning is not found to be urgent in municipal planning. Budgetary and capacity issues within the department were singled out by the respondents as being the main cause for not implementing adaptation policies and plans.

Actors were also asked how they would apply adaptation to their water supply system in the face of climate change. The most common response was to recycle and/or re-use water (*n* = 5), with groundwater abstraction and rainwater harvesting at a household/end user level being the second most popular (*n* = 3 for each). Thus, the recycling and re-use of grey water/treated effluent is the most popular desired behavioural approach to adaptation amongst actors interviewed, which they would implement in their municipality given the opportunity. When comparing these results to what the views and behaviours of WSM were, several differences are apparent. Where groundwater development was the most popular desired WSM behaviour, waste-water recycling is the most desired adaptation behaviour. This shows a clear mind-set difference between how actors perceive WSM, and how they approach managing water in the face of climate change within their municipality. The water supply interventions favoured by the municipalities, i.e. desalination and groundwater abstraction (presented in **section 4.2)** are, as discussed, not necessarily highly sustainable options. These approaches have a narrower focus on the ability to increase the municipality's water supply. whereas the adaptation options discussed consider environmental aspects far more, such as water re-use, which as discussed in **section 2.1.4.2** and **section 4.2**, is the most sustainable water augmentation measure. Both the favoured water supply increase measures mentioned in **section 4.2,** and the response regarding desired adaptation options, are focused on getting the municipality to steer away from surface water, whilst less favoured options such as collecting stormwater and rainwater harvesting still rely on rainfall, they tend to

maximise the intake of rainfall and prevent wastage. However, adaptation measures tended to focus on minimising wastage (as with water recycling) and improving access to resources already obtained (clearing of watercourses, collecting stormwater runoff, continuing conservation efforts, and encouraging household resilience through rainwater harvesting). A full list of responses is given in **Table 4-2.**

Table 4-2: All responses for views on how actors would adapt their water supply system in the face of climate change, as given by respondents.

View	Method	No. of actors
Adaptation of water supply system	*Wastewater re-use*	4
	Rainwater harvesting	3
	Groundwater abstraction	3
	Stormwater capture and storage	2
	Desalination	2
	Clearing of waterways to improve flow and water level	2
	Improve storage capacity of reservoirs	2
	Continue WDM measures	1
	Remove siltation build-up from dams	1
	Change irrigation techniques and move away from heavy water use agriculture in the area	1
	Reduce evapotranspiration through covering open canals	1

When comparing adaptation options expressed by the respondents (as shown in **Table 4-2)** to the adaptation strategies as expressed by Hallegatte (2009), as discussed in **section 2.1.3**, it becomes apparent that the preferred adaptation options could fall into the category of "no-regrets" strategies. These options, such as wastewater re-use, groundwater abstraction, and rainwater harvesting, all look to increase the yield of the existing water supply, as a result of the fact that the majority of the municipalities within the WCDM, as shown by the DWS (2015), are already water stressed and will suffer further water stresses due to population

growth alone. Thus, improving supply would a good investment even without the risks of climate change. Furthermore, several options fall within the EbA category as discussed by Munang et al (2013) in **section 2.1.3**, such as the clearing of waterways, which will improve ecosystem services by improving the ecosystems in these waterways, as well as having less water taken out of these waterways by alien invasive species of plants.

The following section will look at how the local municipalities in the WCDM are, or are not, incorporating climate change adaptation into their planning, by taking a closer look at the relevant local municipalities IDP's. These framework documents outline the planning for the municipality over a five-year period, and thus provide insight into the priorities of the municipality.

4.4.2 Local municipal responses to climate change

Climate change adaptation was highlighted in several local municipality IDPs. IDPs were examined for evidence of climate change adaptation as they are a high-level plan for an entire municipality and provide an overall framework for the development of the municipality.

Within the Bergrivier Municipaliy's IDP (Bergrivier Municipality, 2017a), reference is made to stormwater infrastructure requiring improvement to assist with flash flooding in the case of intense rainfall. This was mentioned in the previous section by actor BM 1. Whilst the municipality has upgraded its stormwater system to deal with more intense rainfall, it has not yet planned to divert excess stormwater into storage, as a joint flood prevention and water resource management measure. However, the approach of joint flood prevention and water resource management is specified in the IDP as a potential adaptation measure for water management. Further adaptation planning present within the IDP involves the removing of alien vegetation in the Berg River to enhance base-river flow and increase the level of the river, thus enabling more water to be abstracted from the river. This process was confirmed as having been completed by the actor BM 1. These findings suggest that the Bergrivier municipality is being proactive, to some extent, with regards to their adaptation plans and strategies.

Within the Swartland Municipality's IDP (Swartland Municipality, 2018), mention is made of climate change risks in general, including water related risks, as well as how steps need to be implemented to mitigate and reduce the projected impact of climate change. One actor from the Swartland municipality did mention adaptation measures such as household rainwater harvesting and capturing stormwater run-off for storage, however the actor was sceptical of these measures as he/she felt that reliance on rainfall for water storage was not a wise decision, considering the climate change projections of less frequent rainfall. The municipality's awareness of climate change and its impacts are an important step in the right direction, however the municipalities need to build resilience and adapt the municipality's water supply, which is largely dependent on surface water (DWS, 2015), to accommodate for the projected climate change impacts. Building resilience can include adopting a conjunctive

use approach, utilising various sources of water, and moving reliance away from just surface water or groundwater.

The Saldanha Bay municipality IDP (Saldanha bay municipality, 2017) appeared to make no reference to climate change adaptation. However, the IDP did make note of projected climate change impacts, as well as relating these to water supply and the associated risks. Whereas the Saldanha Bay municipality's IDP made no reference to climate change adaptation specifically, it did include goals to increase resilience towards climate change in general, yet with no set plan or policy in place. These goals consisted of including climate change considerations into decision making and planning, and to incorporate the West Coast District Municipalities Climate Change Response Framework into their planning. Within the Matzikama municipality's IDP, no reference is made to climate change adaptation, yet general climate change impacts and risks are listed. Both municipalities are expected to have water shortfalls by 2020 (DWS, 2015) and given that the municipalities both understand the projected impacts and risks of climate change on their water supply, from what was said by the respondents, it might have been logical to expect that the municipal actors would give adaptation greater focus.

Within the Cederberg Municipality IDP, reference is made to climate change increasing the impact of drought and water scarcity, yet no adaptation plans or strategies are mentioned (Cederberg Municipality, 2018). Actors within the Cederberg municipality tended to favour adaptation options such as increasing dam storage capacity and groundwater abstraction, approaches already performed under their water management approach, when discussing climate change adaptation in their water management. Surface water and groundwater are potentially at risk due to climate change, and changes to the approach of water management would therefore seem required in this municipality. However, as shown by the DWS (2015), towns within Cederberg are unlikely to experience water shortfalls within the next year or even 2030, and this could explain the lacklustre approach to adaptation within the municipality. This was similar to towns within the Matzikama municipality, and the distant risks could also explain why the Matzikama IDP (Matzikama Municipality, 2012) did not refer to climate change or climate change adaptation.

4.4.3 Water resources adaptation in response to climate change

Climate change is often viewed as a long-term issue, and thus is side-lined in favour of what are perceived as more pressing, immediate issues (Koch, Vogel, and Patel, 2007). Adger, Huq, Brown, Conway, and Hulme (2003) argue that climate change adaptation needs to be balanced with development, particularly in developing countries, where meeting the needs of the people come first. However, Howlett (2014) states that individuals involved in decision making around natural resource management are often described as being "risk averse", thus not likely to put policy forward unless the nature of the problem is pressing, such as poverty. This could be related to scepticism on climate change, and the overwhelming need to deal with issues of poverty. One can link this disjuncture between being aware of climate change,

and yet not acting on it, to the complex problem of linking attitude, perceptions, knowledge, and individual values, to behaviours (Kollmuss & Agyeman, 2002). Kollmuss & Agyeman (2002) look at the connectedness between environmental knowledge and awareness and pro-environmental behaviour. They note that whilst a person may exhibit environmental knowledge or awareness of an environmental issue, they do not necessarily display environmentally friendly behaviour, such as recycling, saving water, cutting carbon emissions etc. Kollmuss & Agyeman (2002) point out various aspects, which under certain circumstances can be more influential in linking awareness and views to behaviours, such as demographic factors (gender, length of education), and internal and external factors (e.g. values, attitudes, emotions, and economic, social, and cultural factors).

Whitmarsh (2007) argues that individuals are more likely to act or be concerned about climate change if they have experienced it first-hand, and perhaps the policy makers within the local municipalities of the WCDM do not foresee climate change as being an immediate threat, and are therefore not prioritising it. Institutional and technological lock-in may also play a role in the slow uptake of climate change adaptation (Könnölä, Unruh, and Carrillo-Hermosilla, 2005; Helm 2010). Könnölä, Unruh, and Carrillo-Hermosilla (2005) describe this as a persistent state which creates systemic barriers to alternatives, be they technological or institutional. Foxon (2002) clarifies the definition of institutional lock-in as any form of constraint that institutions devise to shape interaction within the organisation. These constraints include formal constraints such as legislation, economic rules, contracts, and informal constraints such as social conventions and codes of behaviour which inform norms (Foxon 2002). Institutional lock-in has various implications for water management and climate change adaptation as actors at the municipal level are often limited in the scope of what they can do by legislation, and regulation. Further to this issue of institutional lock-in, is one of hierarchical governance structure (Primmer et al., 2015). Primmer et al. (2015) states that sectorial interest are the main issue in hierarchical governance i.e. the interests of those at the top come before those at the bottom. A solution to this is through a process of collaborative governance (Margerum and Robinson, 2015), in which a process of collectives and partnerships are used to navigate the increasing complexity and competition in the realm of natural resource management.

5 The social networks of municipal actors

The nature of an individual's social network and of their social ties have been shown to have an influence on that individual's views and behaviours (Ibarra & Andrews, 1993; Leombruni, 2015; Kempe et al, 2015), and this can lead to the sharing of views and behaviours between ties. The sharing of a strong tie, or a multiplex tie (e.g. both friend and colleague), has been shown to increase the likelihood for shared views and behaviours between the nodes in a network (Crona et al., 2011). In this chapter the characteristics of the ties of the individual respondents will be examined, as well as the respondents' perceptions on shared views and behaviour within their given social network. This research will then look at how the strength and nature of the ties may influence the sharing of views and behaviours within the actors' given social network.

5.1 The strength of municipal ties

Tie strength was measured using three criteria: dependency, intensity, and affect, as shown in **Table 3-1**. Strength of the ties is calculated using the formula as shown in **Figure 3-2.** The three criteria of tie strength have been shown to be interlinked and to relate to one another (Krackhardt, 1994), i.e. the more dependent a tie becomes on another, the more likely they are to interact frequently (have a high intensity). In turn, this high intensity may foster feelings of positive or negative affect to the tie.

As elaborated in **section 3.4.3**, dependency was measured in terms of how reliant an actor stated they were on a node. Most actors (n = 7) exhibited a strong ($x \geq 4$) dependence on their given social network. In the few cases (n = 4) were there was an average or weak ($x < 4$) dependence, this was usually attributed to the tie sharing poor information, such as out-of-date data or poor advice. The majority of actors (n = 9) showed a high intensity with most of their ties ($x \geq 4$) (see **Table 3-1**), with no defined reasons being given. Affect tended to be of a fairly average strength ($4 < x < 7$) for all actors (see **Table 5-1**). Where a low affect was scored this tended to be as a result of increased conflict between the actor and the tie. Hence, overall, tie strength tended to be strong among the majority of respondents as shown in **Table 5-1**, with the majority of ties (39 out of 50) being strong ($x > 13$). Of these strong ties, seven were considered to be very strong ($x > 17$).

Conflict was noted in a few cases to be a contributor to weak ties. When conflict was exhibited it was attributed to differing outlooks on how water should be managed, or aspects of climate change, such as with actors from the Cederberg Municipality, who disagreed regularly with the local Water Users Association (WUA), local farmers, and the Department of Water and Sanitation on matters of water usage and licensing. A WUA is defined in chapter 8 of the NWA as a co-operative association of individual water users, who wish to undertake water-related activities for the mutual benefit. This relationship could potentially impact water management in the Cederberg municipality, as WUAs are intended to provide for cooperative usage and management of water-related activities for the mutual benefit of members. If this

cooperative nature fails due to conflict, then the role of the WUA essentially becomes defunct, which will have negative consequences for combined water management in the region of the WUA, which is usually localised around a particular water source or group of water resources. A similar relationship was noted with the actors from the Cederberg municipality and the WCDM. A poor relationship with the WCDM could imply that the municipality is not receiving sufficient support in terms of its water management from the WCDM, which could result in the Cederberg municipality not building resilience for climate change and associated impacts on water management. It was noted in the literature review, namely through the works of Bodin et al. (2011) and Crona et al. (2011), that effective natural resource management relies on collaboration and coordination amongst various stakeholders. A lack of collaboration and opposition to new innovative ideas, could severely hamper water management in local municipalities within the WCDM.

Contrary to Krackhardt (1994), in which it is theorised that a strong dependency will result in a strong intensity, and thus a strong tie, it was found that there were seven connections where a tie had low dependency ($x \leq 3$) and a strong intensity ($x = 5$). In one case, a very low dependency ($x = 1$) was matched with a high intensity ($x = 5$). This particular actor (SBM 1) was required to interact frequently with the Western Cape's Disaster Risk Management team on matters of climate change and environmental risk. However, the actor felt the advice and support given by Disaster Risk Management team was insufficient. According to Krackhardt (1994) this would likely lead to a low affect, as the potential feelings towards the tie would be negative. However, the respondent SBM 1 reported that there were no ill feelings, and no conflict between the actor and the tie. This particular relationship, whilst not negative, does not promote a strong support structure for aspects of climate change and building resilience. It is theorised that relations such as these may build apathy and a lack of interest may form in the actor's role. This is backed up by the actor stating that they were pessimistic in their views regarding the environment and climate change, when compared to that of their advice network. This research will now look at how the above aspects of strength of ties combine to form strong or weak ties, and how these aspects relate to the formation of multiplex ties.

McPherson et al. (2001) define a multiplex tie as a tie which involves several types of relationships. Within this research, a tie with multiple relationships is defined as one where the tie is both a friend and a colleague. Quantitatively this is defined as a tie where the total affect is higher than 7 out of 10 (strong or very strong according to **Figure 3-3**). In total, five actors exhibited multiplex ties within their given advice networks (see **Table 5-1**). The rural nature of the West Coast District may play a role in the formation of multiplex ties. Rural networks are theorised to be smaller and denser than urban networks (Buchel & Ehrlich, 2016; Rockenbauch and Sakdapolrak, 2017). Support for this idea is provided by the actor BM 1 (Bergrivier municipality), who states that strong intimate relationships between municipal actors are common in small towns, as is illustrated with the following quote:

"We are friends, but we are also colleagues. We were not friends before and then became colleagues; we were colleagues and became friends. But in a rural municipality it is like that; I'm also friends with our mayor and friends with my peers" (Respondent BM 1, Bergrivier municipality).

In **Table 5-1**, an overview of the strength of ties for each actor are given, with multiplex ties highlighted.

It is also worth noting that the majority of ties (*n* = 36 out of 50) were external ties, i.e. outside of the actor's municipality. This implies that the actors are looking outside of their municipality for advice on climate change and water management. External ties (Woolcock, 1998; Babaei, Ahmad & Gill, 2012) connect actors to outside sources of information and support. These ties are considered important for leveraging resources, ideas, information, and technologies, beyond the level of the local communities, or in this case municipalities (Bodin & Crona, 2009). Whilst several of these external ties might be necessitated through institutional structures, such as through the hierarchical approach to environmental management or water management, whereby for example local municipal actors must apply to provincial or national governments for licenses or authorisations, several appear optional. Ties with external research bodies, such as universities and consultants, would seem optional, bringing in external expertise to assist small local municipalities in aspects of water management and climate change adaptation. The reliance on these external ties are a sign of positive steps towards creating resilience, and a richness in the information and support required to become more resilient.

Table 5-1: Summary of each actor's ties (categorised by municipality) and their relative strength, in terms of the various categories of measurement, as well as an overall measurement of strength of the tie. Ties identified as being multiplex are highlighted in green. All multiplex ties were either strong ties (13-16 out of 20) or very strong ties (17-20 out of 20).

Actor	Tie (internal or external)	Reliance	Total Affect	Frequency of interaction	Total strength
MM 1	Internal tie	5	6	5	16
	External consultant	3	6	5	14
	External gov. dept.	3	6	4	13
	External consultant	3	6	5	14
	External Water Users Association	4	6	5	15
MM 2	Internal tie	5	6	5	16
	External consultant	4	6	5	15
	External Consultant	4	6	5	15
BM 2	Internal tie	5	9	5	19
	External gov. dept.	4	8	4	16
	External gov. dept.	4	9	3	16
	External water board	4	9	4	17
	External gov. dept.	4	9	3	16
BM 1	Internal tie	3	6	5	14
	External gov. dept.	5	4	4	13
	External gov. dept.	3	5	5	13
	External consultant	3	7	5	15
	Internal tie	2	4	5	11
CM 1 and 2 (shared ties)	External gov. dept.	5	6	5	16
	External water user's association	5	3	4	12
	External gov. dept.	3	3	1	7
	External gov. dept.	5	6	5	16
	External / farming community	1	3	1	5
	Internal tie (between two actors)	5	6	5	16
SM 1	External gov. dept.	3	9	4	16

Actor	Tie (internal or external)	Reliance	Total Affect	Frequency of interaction	Total strength
	External gov. dept.	3	9	4	16
	External gov. dept.	4	9	4	17
	External support (University)	4	9	1	14
	Internal tie	4	9	1	14
	External gov. dept.	3	9	1	13
	Internal tie	5	9	5	19
SM 2	Internal tie	5	6	4	15
	Internal tie	5	6	4	15
	External gov. dept.	5	6	3	14
SBM 1	External gov. dept.	3	9	4	16
	External gov. dept.	1	6	5	12
	External gov. dept.	2	6	3	11
	External gov. dept.	4	6	3	13
	External gov. dept.	5	9	5	19
SBM 2	External gov. dept.	5	5	4	14
	External gov. dept.	5	4	3	12
	External gov. dept.	5	5	1	11
	External consultant	3,5	5	4	12,5
	External gov. dept.	3,5	5	4	12,5
	Internal tie (municipal council)	5	6	4	15
SBM 3	External gov. dept.	5	6	4	15
	External gov. dept.	3	5	4	12
	External gov. dept.	5	5	4	14
	Internal tie	5	8	5	18
	Internal tie	5	8	5	18

5.2 Sharing of views and behaviours, and the influence of advice networks

Similarity breeds connection, and as the saying goes, "*birds of a feather flock together*" (McPherson et al, 2001: 415). All respondents except for one stated that they believed their views to be shared by their given advice network and their desired behaviours aligned with their municipality. Of those respondents six believed their behaviours were approved of by their given advice network, whilst four actors believed that their descriptive norms were aligned with their municipality. In this section the common aspect of the sharing of views in relation to water management, climate change, and climate change adaptation, and whether aspects of tie strength and multiplexity influence the sharing of these views will be explored, and then the sharing of behaviours applying the same process of assessing strength of ties and multiplexity.

5.2.1 The strength of ties, multiplexity, and the sharing of views

As all actors, barring one, believed their views to be shared with their given advice network, there is little to support that the strength of ties between the actor and their given advice network, or multiplexity with a given node, had any influence on the actors' sharing of views with their advice network. Furthermore, whilst the majority of ties were strong ties, actors who had weak ties with nodes, as per **Table 3-1** also expressed a sharing of views with those nodes. Krackhardt (1994) and Leombruni (2015) both show that a strong tie will likely result in the sharing of views. The sharing of views occurs because individuals who are more closely tied to others are more intimate, and are thus more motivated to share (Haythornthwaite, 1996; McPherson et al, 2001). As discussed in **section 2.2.1**, strong connections are likely to have more than one type of relationship, i.e. both friend and colleague (McPherson et al., 2001), therefore ties which exhibit a sharing of views are often anticipated to be multiplex (McPherson et al., 2001). However, not all ties which shared views exhibited multiplexity, and in one case, a multiplex relationship did not have shared views, and this is discussed further below.

Five actors who believed their views and behaviours were shared (n = 5) had multiplex ties with their given advice network. In one case (BM 1; see **Table 5-1**), the existence of a multiplex tie did not result in shared views or behaviours with their given advice network. However, in the Matzikama municipality, both the actors MM 1 and MM 2 were shown to have no multiplex ties with their given advice network (see **Table 5-1**), yet stated that they both believed their given views and behaviours were shared with their network. It thus seems that the existence of a multiplex tie does not increase the likelihood of shared views or behaviours between the municipal actor and their given advice network.

As stated above, the existence of multiplex ties appears to have no bearing on the sharing, or not sharing, of views between the respondent and their given advice network. Although the majority of ties were ranked as strong (**Table 5-1**), both strong and weak ties resulted in the perceived sharing of views between the actor interviewed and their given advice network. An

example of this can be taken from the Cederberg Municipality, where the strength of the tie between the municipal staff and local farmers is very weak (x = 5), yet the municipal actors believe that their views are shared by the farmers. Conversely, in the same municipality a strong tie (x = 16) exists between the actors and the DWS and this tie is also believed to share the views of the actor. A respondent at the Cederberg municipality believed that the sharing of views, particularly around water demand and supply management, was related to a shared experience.

"It's not because all of us are fighting for water; we need it to provide it to our users, to the consumers […]. *So, we are fighting in the same space for a resource that we are sharing. So, farmers, for instance, understand* [that] *if they over-abstract, there will be issues for all users." (Respondent CM 1, Cederberg Municipality).*

The above quote gives the perspective that the sharing of views for the topics of water demand, and WSM, is based on a common or shared experience. It is already noted that the actors from the Cederberg municipality have a poor relationship with the local farmers, however, as shown by the above quote, the municipality and farmers both understand that an over-use of water will result in consequences for all users. Thus, the actors believe that their views on water demand and supply management are shared by water users within the municipality. In further support of the theory of views being shared due to a shared experience, a respondent from the Bergrivier Municipality stated that climate change is physically felt by all, and is discussed amongst his/her advice network. The usage of us/we in his/her wording adds to this by showing that the feelings and/or experiences of climate change are shared with his/her advice network and colleagues at his/her municipality.

"I think we feel it on our bodies. We see it [climate change]*; it's not something someone teaches you from a theory book – we experience it, so you can't not believe it because we've seen it with our own eyes. We see it every day. We are becoming a semi-desert – that's never been the case. Also, we talk to one another; we share information." (Respondent BM 1, Berg River Municipality).*

The above quote incorporates the actor's views, as well of those of his/her advice network, by utilising the plural "we". Van der Linden (2015) notes that experience of climate change influences individual perceptions of climate change. In other words, the physical experience of individuals (i.e. noticing less rainfall, feeling the weather getting warmer, noticing more frequent intense storms etc.) or lack of experience, will influence the perception individuals have on climate change. Other literature (Spence et al. 2012) has noted that people are more likely to act on issues such as climate change after having first-hand experience of the impacts and effects. Similarly, Whitmarsh (2007) also reports in their study that individuals who have experienced impacts of flooding and air pollution, are more likely to have pro-environmental values, and are more likely to consider climate change a salient risk. Whilst a strong tie or multiplex tie is expected to result in the sharing of perceptions of climate change and water management, it would appear in the case of this study that a shared, lived experience, might

exert a stronger influence on the sharing of these views. The actor SM 2, noted in **section 4.3**, who claimed to be sceptical of climate change when questioned on his knowledge, still showed an experience of climate change, and thus this could be a reason why he/she shared views with his/her advice network.

Some actors (*n* = 4) pointed to the fact that views are shared because of hierarchy, or more specifically, legislation. This influence by legislation and/or hierarchy implies that their views are influenced by social norms, the definition of which has been broken up into two areas, descriptive norms, and injunctive norms (see **section 2.2.2**), i.e. what is commonly done and what is commonly approved (Cialdini et al., 1991). The concept of norms is explored further in **section 5.2.2**. However, these shared views and behaviours could be explained by the concept of institutional lock-in, which was defined earlier in **section 4.4.2,** as being a state that creates systemic barriers to alternatives, be they technological or institutional (Könnölä, Unruh, Carrillo-Hermosilla, 2005). The possible influence of institutional lock-in on actors is best shown with the following two quotes from respondents in the Swartland and Bergrivier municipality.

"*It's quite simple – we must meet certain goals [on] water management, and we've got points for that* […] *if we don't comply, we don't get the right ticks, so it shows on management. So, they* [management] *will put pressure on us to comply" (Respondent SM 2, Swartland Municipality)*

"…everything is legislated. So, if national government believes in adaptation then all of us do and we must comply, and the Audit General comes around once a year to see that you comply. So that system is brilliant because if you want to change something, you put it in at the top as legislation. So, if you want to change people's thinking about climate change, you put it as legislation." (Respondent BM 1, Bergrivier municipality).

The first quote explores how views on water management (demand and supply) are guided by goals and targets, which are usually set by the provincial Department of Water and Sanitation, in order to ensure that municipal water supply meets national and provincial standards. The second quote, referring more to climate change adaptation, shows that in order to mainstream adaptation, it must come from the national level down in the form of legislation. The actor believes that if it is legislated, then the appropriate views and behaviours will follow. However, enforcing views through institutions could potentially lead to alternative, innovative policies for climate change adaptation and WDM potentially being over-looked. This relates back to the points made in **section 4.4,** where water re-use was identified as one of the more sustainable water supply options yet was not favoured by the actor's municipalities.

It has been noted above that one respondent stated that they did not believe their views were shared with their given advice network. The role of this respondent was that of an Environmental Officer. They believed their views on climate change, climate change

adaptation, and water supply and demand management were more pessimistic than the views of the other actors in their advice network. In terms of pessimism, the actor held the view that little could be done to improve the drastic situation of climate change. The Environmental Officer simply believed that those within their given advice network did not view environmental issues as being of great consequence, and this made the actor feel that there was little they could do themselves to make an impact. This pessimistic / optimistic issue could be related to what Barr (2007) refers to as a psychological variable, namely, the perception of an environmental problem, in which an actor's views and beliefs are influenced by their own perception of the problem. Furthermore, as noted above by Van der Linde (2015) aspects of knowledge and experience may also influence this actors' perceptions. This could also link up to what Kollmuss & Agyeman (2002) stated on environmental knowledge and awareness and pro-environmental behaviour. An actor with strong environmental views and values, knowledge on the issue, and that is within a social circle that supports their values and education, would likely exhibit pro-environmental views and behaviours. Whilst this actor may have extensive knowledge on environmental and climate issues, they feel their advice network does not, and this causes them to be pessimistic about the future of climate change adaptation in their municipality and more regionally. This apathy is problematic, as it might cause those with the knowledge to act and influence change to accept procedure and process and become indifferent.

It was also noted that views between actors and nodes which are not within the governmental structures of the municipalities, such as private consulting firms, universities, or engineers, are also shared. Sharing of views in these cases could be linked to sharing similar lived experiences or sharing similar sources of information. However, "technological lock-in", which is similar to institutional lock-in, could be a more likely explanation for sharing of views with external ties, particularly in aspects of WSM and climate change adaptation, which often involve technological aspects. Klitkou, Bolwig, Hanse, and Wessberg (2015) describe technological lock-in as being a set of positive feedbacks or increasing returns to the continued adoption of a selected technology. This ultimately gives current technologies an advantage over new technologies as they are more widely used and embraced. A key factor to this is that the associated costs and performances of a new technology would be more uncertain. Foxon (2002) describes both institutional lock-in and technological lock-in as being barriers to sustainable development. The implications of these barriers are that innovative technologies for water management, and climate change adaptation options, are generally overlooked, resulting in the use of tried and tested techniques, which are not always the most sustainable (Foxton, 2002). Foxon (2002) states that innovation has often been key in solving environmental issues, by providing a range of positive externalities, creating options for substitution, mitigating against uncertainties, and enabling environmental problems to be solved sooner than they would otherwise. It would thus seem that ways to break institutional and technological lock-in need to be explored by local municipalities in the WCDM and higher levels of government. Granovetter (1973) and Grafton (2005), as discussed in **section 2.2** of

the literature review, show that weak ties can play an important role in introducing new information and views into the network. Therefore, actors in local municipalities in the WCDM could benefit from expanding their networks to include weak ties and thus open themselves up to new and innovative views and behaviours. This could assist with the adoption of new technologies and strategies for climate change adaptation in the water management sector, particularly at higher levels of government where the bulk of decision making around water management is made.

5.2.2 Common municipal behaviours and the influence of advice network ties

Behaviours are described according to the influence of two categories of norms, namely injunctive norms (which in this research are shared with the actor's advice network), and descriptive norms (shared with the actor's municipality) (see **section 2.2.2**). As noted above, 10 actors believed their behaviours were commonly approved of by their given advice network, and of these, 6 believed their behaviours were shared with their municipality, whilst 4 actors believed their behaviours were only aligned with their advice network and not their municipality. One actor did not believe their behaviours to be approved of by their advice network, nor shared by their municipality. Thus, only a small majority of actors (n = 6) believed that their preferred behaviours were shared by their municipality and approved of by their given advice network. This shows that the majority of actors were behaving within the realms of institutionalised municipal behaviours when acting on aspects of water demand and supply management, and climate change adaptation. This behaviour relates to the results shown in **section 5.2.1,** where it was shown that most actors' views related strongly to aspects of institutionalised norms, theorised to be influenced by institutional lock-in. The four respondents who believe their preferred behaviours were not aligned with their municipality relate to what was discussed in **section 4.4.2**, whereby what the actors would like to do (behaviours) were often not aligned with what the municipality was actually doing.

In terms of descriptive norms with the actor's municipality, two respondents (n = 2) stated that they believed their preferred behaviours were aligned because their behaviours are largely based on what is legislated or guided via policy. Other respondents (n = 4) believed that their preferred behaviours were shared with their municipality due to the hierarchical structure of their municipality, and that their behaviours were based on what their managers did. This relates to the hierarchical governance structure discussed in **section 4.4.2** (Primmer et al., 2015), as well as aspects of institutional lock-in. Furthermore, these six actors also believed that their preferred behaviours were aligned with their given advice network. This alignment, and influence from hierarchical governance and institutional lock-in, potentially indicates that the actors and their advice network are less likely to make decisions outside of what has historically been done, or approved of, in terms of water management, and thus do not engage in resilient climate change adaptations around water management. This lock-in and hierarchical approach to governance would therefore likely limit the scope of new or inventive technologies, policies or behaviours from being accepted within the actors'

municipalities or advice networks. By not bringing in, or being open to, new ideas and technologies, municipalities risk falling into the trap of the so-called "Hydro-Illogical Cycle". Wilhite (2012) describes the Hydro-Illogical Cycle as being the reactive response to issues of drought or water scarcity only when it becomes severe. Due to the cyclical, yet unpredictable, nature of droughts and the increasing impact of them due to climate change, this practice continues. The cycle of drought, followed by raising awareness of water issues, concern, panic and rushed action to resolve the issue. This is eventually followed by relieving rainfall, leading to apathy and relaxation, which means that nothing pro-active gets done in becoming resilient to the issues of drought and climate change (Wilhite, 2011; 2012). The role of adaptive capacity, as raised by Nelson, Howden, and Smith (2008), shows that raising adaptive capacity through new, or not commonly recognised research, plays an important role in alleviating the impacts of drought when they occur. Focusing on newer research and innovative ideas leads to more adaptive capacity through integrating local knowledge and creates a flexible drought policy which can be integrated at a regional scale (Smith et al., 2008). Therefore, it is important that municipal actors' step outside of what is commonly done in terms of their institutions and engage in innovative research and ideas to create stronger adaptive capacity within their water management and climate change adaptation policies.

As with the sharing of views, it was noted that both multiplexity and strength of ties with the actors' given advice network appeared to have no bearing on the perceived sharing of behaviours with the actor's advice network or the actor's municipality. Both strong and weak ties resulted in the sharing of behaviours, both injunctive and descriptive, and the existence or otherwise of a multiplex tie resulted in the same.

The respondents from the Cederberg Municipality believed that common behaviours are often aligned due to a shared experience between the actors and their advice network, which relates back to what was discussed in **section 5.2.1** regarding the possibility that shared experiences lead to shared views, and strengthens the findings of literature that suggests how knowledge and experience of climate change in particular, leads to more pro-climate change views and behaviours (e.g. Whitmarsh, Spence, van der Linden). The respondents at Matzikama Municipality believed that within their municipality, behaviours were aligned within the municipality due to the small size of the municipality, and the lack of positions filled. McPherson et al. (2001) state that homophily is powerfully affected by the relative size of groups, which relates to McPherson's (1991) comment that social contact in small systems is usually multiplex, in that all connections amongst the actors in small communities tend to have multiple components. However, as discussed above, multiplexity appeared to have no bearing on the sharing of views and behaviours between the actor, their advice network, and their municipality.

The aspect of conflict in the social network of the environmental officer could play a role here, particularly as the environmental officer alluded to a level of conflict in their social network, stating that environmental concerns do not appear to be of great importance within their

municipality. The role of the Environmental Officer, as stated by the respondent, is often more of a commenting authority. This is particularly relevant in aspects of water management, where projects are implemented and executed within the water management department. The role of the environmental officer therein is to ensure that the projects comply with relevant legislation and laws. As stated by the environmental officer, "*Decisions are often predetermined, and it is the role of the Environmental Officer to ensure compliance with the relevant laws rather than make decisions on what projects to implement"*. This predetermination and exclusion of an environmentalist or someone skilled in determining aspects of sustainability could potentially lead to more sustainable, environmentally friendly options of water supply being excluded from planning. However, legislation such as the National Environmental Management Act (NEMA) and the National Water Act (NWA) do provide for the consideration of sustainability and environmental impact in the decision-making process. So, whilst they do not preclude the development of large-scale surface water storage, such as dams, or abstraction of groundwater, which if ill-managed may be unsustainable, sustainable and environmental considerations are brought into these measures through the authorisation process. The competent authority, such as the DWS in the case of water use authorisations, or the Department of Environmental Affairs and Development Planning (DEADP) or Department of Environmental Affairs (DEA) in the case of environmental authorisations, may specify that certain management or design specifications be included in the development of water resources to ensure impacts are kept to a minimum. The role played by the environmental officer is therefore very important in ensuring compliance with various applicable legislation, and this is reflected in their strong ties with the DEADP and DEA in both cases.

The influence of institutional, technological lock-in, and hierarchical 'top-down' governance has been theorised to exist in both the sharing of views and behaviours within the various respondents' given social networks. Whilst the influence of lock-in can seem quite vice-like in social networks, it has been noted that social networks are also extremely important for the emergence, and spread, of new norms (Paluck, Shepherd & Aronow, 2016). In the case of local municipal governments, it is important for these actors to have a diverse array of strong and weak ties which would assist in challenging the entrenched norms and introduce new norms. Crona et al (2011) states that if a member of the social network with a high status can be persuaded to adopt a new view or practice, the strong ties within the network can assist with the diffusal of new ideas and the adoption process. As discussed earlier, the works of Wilhite (2011; 2012) and Nelson et al. (2008) show that embracing new scientific research and sources of information can build resilience and adaptive capacity in the case of water management and climate change.

6 Conclusion

This research aimed to explore the views and behaviours of municipal actors with regards to water management and climate change. Secondary to this aim was to determine if the given advice network of an actor influenced the actor's views and behaviours. By utilising a semi-structured interview process, the chosen actors' views and behaviours were determined, as well as the structure and characteristics of their given advice network. The respondent's views and behaviours on water management and climate change were then compared to climate change projections and outlooks for water management within the municipalities to understand how the municipal actors aimed to overcome the projected impacts and risks of climate change on water in their municipality. Thereafter, using a social network approach based on Krackhardt's (1994) "constraints on the interactive organisation as an ideal type", the strength of ties within the various actors given advice networks were compared to the actors' given views and behaviours. This research then examined and theorised how characteristics of tie strength may have an influence on the actors' given views and behaviours on climate change adaptation and water management, as well as influence the sharing of these views and behaviours between the given advice networks, and the actor's municipality.

In terms of WDM, actors clearly viewed raising awareness as the most effective way to reduce demand yet tended to follow the process of implementing restrictions as a first order approach to reduce demand, thereafter, using the combined effect of raised water tariffs as a tool to raise awareness, along with additional awareness campaigns to reduce demand. With regards to WSM, actors tended to view both improving maintenance of the existing water supply, as well as finding alternative sources of water, as effective methods to increasing existing supply. However, the overwhelming behavioural response was sourcing alternative sources of water to expand their supply. The impact of climate change on water resources was clearly understood by actors. Furthermore, actors tended to have a clear understanding of adaptation and the role it plays in water management in the face of climate change. The majority of actors also believed that the best way to adapt to climate change, in terms of water management, was to utilise alternative sources of water not related to surface water abstraction and storage. This included the treatment and usage of wastewater, groundwater abstraction, and sea-water desalination. However, it was noted that in most municipalities no clear adaptation plans were in place. Only one municipality, namely the Bergrivier municipality, had made inroads to adapting the water supply to the projected impacts of climate change, for example by clearing alien vegetation in the berg river, improving river flow and allowing for more water to be abstracted sustainably.

Strong ties and multiplex ties have been theorised to contribute to the sharing of views and behaviours between nodes in a social network (Krackhardt, 1994; McPherson et al., 2001; Crona et al., 2012). The strengths of the various ties were measured utilising three areas namely, dependency, intensity, and affect. However, it was noted within this research that

the strength of ties, or existence of multiplex ties, did not appear to have much bearing on the sharing of views or behaviours between the actor and their given advice network. Furthermore, on average the strength of tie between an actor and a node in their network was determined to be strong, however both strong and weak ties resulted in the perceived sharing of views. Therefore, homophily within their social network was theorised to exist more as a result of the concepts of institutional lock-in, technological lock-in, and hierarchical governance.

A social network with entrenched ties can potentially lock-in existing norms, and prevent new norms and views from taking route, which can have negative effects on the management of natural resources such as water in the face of a changing climatic system. A social network with a diverse array of strong and weak ties has been theorised to assist in challenging entrenched norms and introduce new norms (Paluck et al., 2016). To break through obstacles such as institutional lock-in a top-down approach might be important when considering the social network perspective, i.e. a member of the network with a high status and power can influence other members of the network to consider new norms and challenge entrenched norms (Crona et al, 2012). Furthermore, embracing new knowledge and scientific research can build resilience in assist with adaptation in the face of climate change (Nelson, 2008; Whilhite, 2011;2012).

This research has found that whilst municipal actors involved in water management have a clear picture of how climate change may impact their water supply, the reactive responses by actors to issues of water demand or supply can lead to poor resilience in the face of climate change. Additionally, the ability of actors to implement adaptation sufficiently is constrained by aspects of lock-in, discussed above, within and outside of their municipality. The understanding of how social networks influence governance is fundamental to expanding how adaptation to climate change can become more accepted at a local municipal government level. Additionally, understanding views and behaviours of local government actors allows researchers to understand how climate change adaptation can better be implemented within water management in local government. This also gives policy makers a clearer understanding of what needs to be done in terms of implementing sustainable water management practices in the face of climate change, such as implementing conjunctive use approaches to water management, ecosystem-based adaptation, and changing consumption patterns.

A shortcoming in this research was the small sample size of 11 actors. It is thus recommended that future research into the views and behaviours of municipal actors covers a larger interview base. Furthermore, a more quantitative social network analysis approach can yield interesting statistical findings in the strength of ties and how these influence views and behaviours within the advice network. However, this would require a larger, more robust sample group. It is recommended that future research examine how to bring strong and weak ties into a local municipal social network, in order to facilitate the spread of positive climate

change views and behaviours, as well as the implementation of sustainable climate change adaptation projects and strategies. This type of research could be done through a study of influence and power in the social networks present in district and local municipalities. However, as this research uncovered various links to institutional and technological lock-in being influential in the type of strategies employed at a local municipal level, it may be profitable for future research to involve a far larger study area and encompass district, provincial, and perhaps national government. Determining how influence spreads through these social networks will assist the design and implementation of climate change adaptation policy, specifically with regards to water management, and can assist in building resilience in this sector.

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References

Ager, W.N. 2006. Vulnerability. Global Environmental Change. 16: 261-268. DOI: 10.1016/j.gloenvcha.2006.02.006

Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme, M. 2003. Adaptation to climate change in the developing world. Progress in development studies, 3(3), pp.179-195.

Alleby, M. 2015. Ecosystem services. In A Dictionay of Ecology: Oxford University Press. Available: http://www.oxfordreference.com/view/10.1093/acref/9780191793158.001.0001/acref-9780191793158-e-6377.

Amberger, M. 2011. The environmental downside to desalinated water. DW news. Available: https://p.dw.com/p/12LMq

Ambulkar, A., & Nathanson, J.A. 2019. Wastewater treatment. In *Encyclopaedia Britannica*. Available: https://academic-eb-com.ezproxy.uct.ac.za/levels/collegiate/article/wastewater-treatment/471031#72365.toc

Ayres, L. 2012. Semi-Structured Interview. In the SAGE Encyclopaedia of Qualitative Research Methods. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781412963909

Babaei, H., Ahmad, N. and Gill, S.S. 2012. Bonding, bridging and linking social capital and empowerment among squatter settlements in Tehran, Iran. World Applied Sciences Journal, 17(1), pp.119-126.

Baudoin, M-A. 2016. Introduction to climate change adaptation: key concepts. [EGS5032F lecture notes]. African Climate and Development Initiative. Department of Environmental and Geographical Science, University of Cape Town.

Barr, S. 2007. Factors Influencing Environmental Attitudes and Behaviours A U.K. Case Study of Household Waste Management. Environment and Behaviour 39(4) pp. 435-473. SAGE publications. Doi: 10.1177/0013916505283421

Baxter, R.M. 1977. Environmental effects of dams and impoundments. Annual review of ecology and systematics, 8(1), pp.255-283.

Bergrivier Municipality. 2016. Municipality Structure. Available: http://www.bergmun.org.za/municipality-structure [2016, October 5]

Bergrivier Municipality. 2017a. Fourth Generation Integrated Development Plan: 2017-2022

Bergrivier Municipality. 2017b. Annual Water Services Development Plan Performance – and Water Services Audit Report.

Bergrivier Municipality By-Law relating to water supply, sanitation services and industrial effluent. 2009. Province of the Western Cape: Provincial Gazette 6675.

Biernacki, P. & Waldorf, D. 1981. Snowball Sampling. Problems and Techniques of Chain Referral Sampling. Sociological Methods and Research 10(2), 141-163.

Bloor, M. & Wood, F. 2006. Case Study. In Keywords in Qualitative Methods. London, Sage Publications Ltd. DOI: http://dx.doi.org/10.4135/9781849209403

Bodin, O., Ramirez-Sanchez, S., Ernstson, H., Prell, C. 2011. A Social Network approach to natural resource governance. In: Bodin, O & Prell, C (Eds) Social Networks and Natural Resource Management: Unvocering the Social Fabric of Environmental Governance. Pp3-28. Cambridge University Press. Cambridge.

Bodin, O., & Crona, B.I. 2009. The role of social networks in natural resource governance: What relational patterns make a difference? Global Environmental Change 19, 366-374.

Bond, M. & Harrigan, N. 2014. Political Dimensions and Corporate Connections. In The SAGE Handbook of Social Network Analysis. London, SAGE Publications Ltd DOI: http://dx.doi.org/10.4135/9781446294413

Brass, D.J. & Krackhardt, D.M. 2012. Power, Politics, and Social Networks in Organisations. In Politics in Organisation: Theory and Research Considerations. Ferris, R.G. & Treadway, D.C , Eds. New York, Taylor and Francis Group.

Brower, R. 2017. The Capacity of Local Governments to build flood resilience in informal settlements: A social networks approach. Masters thesis. University of Cape Town, Faculty of Science, Department of Environmental and Geographical Science.

Brooks, N. and Adger,W. N. 2004. Assessing and Enhancing Adaptive Capacity, L. B. Lim (ed.). Adaptation Policy Framework. United Nations Development Programme, New York. www.undp.org/cc/apf.htm.

Buchel, K., and Ehrlich, vM. 2016. Cities and the Structure of Social Interactions: Evidence from Mobile Phone Data. CESifo working paper 6568. Available: http://hdl.handle.net/10419/167554

Burger, S. 2018. Lucky Star operations in Western Cape get two desalination plants. *Engineering News*. Available: http://www.engineeringnews.co.za/article/lucky-star-operations-in-western-cape-get-two-desalination-plants-2018-07-11

Callaway, J.M. 2004. Adaptation benefits and costs: Are they important in the global policy picture and how can we estimate them? Global Environmental Change. 14: 273-282. DOI: I0.1016/j.gloenvcha.2004.04.002

Callegaro, M. 2011. Social Desirability. In Encyclopedia of Survey Research Methods London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781412963947

Casanova, J., Devau, N. and Pettenati, M. 2016. Managed Aquifer Recharge: An Overview of Issues and Options. In Integrated Groundwater Management (pp. 413-434).

Cederburg Municipality. 2018. Revision to the Fourth Generation Integrated Development Plan (IDP) 2017-2022.

Chen, Y.Y. and Hong, Y.Y. 2015. Different ways to resolve discrepancy between descriptive and injunctive norms across cultures. Journal of Cross-Cultural Psychology, 46(10), pp.1316-1319.

Christian-Smith, J., Levy, M.C. and Gleick, P.H. 2015. Maladaptation to drought: a case report from California, USA. Sustainability Science, 10(3), pp.491-501.

Cialdini, R.B., and Trost, M.R. 1998. Social influence: Social norms, conformity and compliance.

Cialdini, R.B., Kallgren, C.A. and Reno, R.R., 1991. A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human behaviour. Advances in experimental social psychology, 24, pp.201-234.

Clifford-Holmes, J.K., Palmer, C.G., De West, C.J., & Slinger, J.H. (2016). Operational manifestations of institutional dysfunction in post-apartheid South Africa: *Water Policy 18 998-1014.*

Clifford-Holmes, J.K., Slinger, J.H., De Wet, C., & Palmer, C.G. 2018. Modelling in the "Muddled Middle": A Case Study of Water Service Delivery in Post-Apartheid South Africa. In C.Garcia-Diaz & C Olaya(Eds.), *Social Systems Engineering: The Design of Complexity*. Wiley (ISBN: 978-1-118-97445-2)

Colman, A. 2015. Exploratory research. In A Dictionary of Psychology. Oxford University Press. Online [available] http://www.oxfordreference.com/view/10.1093/acref/9780199657681.001.0001/acref-9780199657681-e-2963.

Conway, D., Van Garderen, E.A., Deryng, D., Dorling, S., Krueger, T., Landman, W., Lankford, B., Lebek, K., Osborn, T., Ringler, C. and Thurlow, J. 2015. Climate and southern Africa's water–energy–food nexus. Nature Climate Change, 5(9), p.837.

Corraliza, J.A., Berenguer, J. 2000. Environmental values, beliefs, and actions: A situational approach. Environment and Behavior (32), 832-848.

City of Cape Town. 2017. Climate Change Policy. City of Cape Town Municipality.

City of Cape Town. 2016. Weekly Dam Levels. Avaible: http://www.capetown.gov.za/en/water/pages/weeklydamlevels.aspx [2016, September 26]

Crona, B., Ernstson, H., Prell, C., Reed, M. & Hubacek, K. (2011) Combining social netwok approaches with social theories to improve understanding of resource governance. In: Social Networks and Natural Resource Management: Uncovering the Social Fabric in environmental Governance. Pp. 44-71. Cambridge University Press, Cambridge.

Crona, B. and Hubacek, K., 2010. The right connections: how do social networks lubricate the machinery of natural resource governance?. Ecology and Society, 15(4).

Crossman, A. 2016. Understanding Purposive Sampling: an overview of the method and it's applications. Availabe: http://sociology.about.com/od/Types-of-Samples/a/Purposive-Sample.htm [2016, October 5]

Cuff, D. & Goudie, A. 2009. Vulnerability. In The Oxford Companion to Global Change. Oxford University Press. Available: http://www.oxfordreference.com.ezproxy.uct.ac.za/view/10.1093/acref/9780195324884.001.0001/acref-9780195324884-e-237?rskey=JSYO9p&result=3 [2016, October 2].

Custudio, E. 2000. Effects of groundwater development on the environment. Boletin Geologico y Minero. 111(6). 107-120.

Delfau, K. 2017. Understanding supply-side and demand-side to support water management in the Asia Pacific. Available: https://kini.waterpartnership.org.au/posts/2720426-understanding-supply-side-and-demand-side-to-support-water-management-in-the-as

Department of Environmental Affairs (DEA).2013. Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa. Pretoria, South Africa.

Department of Environmental Affairs. 2012. National Climate Change Response White Paper. Pretoria: Department of Environmental Affairs.

Department of Government Communications and Information System. 2018. South Africa Yearbook 2017/18. Ed. Miriam Mokeoena.

Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 years of Artificial Groundwater Recharge. PRSA 000/00/11609/10 – Activity 17 (AR5.1), dated August 2010.

Department of Water Affairs. 2013. National Water Resource Strategy. Water for an equitable and sustainable future.

Department of Water Affairs and Forestry. 2007. Western Cape Water Supply System Reconciliation Strategy Study: Overview of Water Conservation and Demand Management in the City of Cape Town. Prepared by W Ketteringham of UWP Consulting (Pty) Ltd.

Department of Water and Sanitation. 2016. Support to the Continuation of the Water Reconciliation Strategy for the Western Cape Water Supply System: Status Report April 2016. Prepared by Umvoto Africa (Pty) Ltd in association with WorleyParsons RSA on behalf of the Directorate: National Water Resource Planning.

Department of Water and Sanitation. 2015. Support to the Implementation and Maintenance of Reconciliation Strategies for Towns in the Southern Planning Region: Status Report Western Cape – October 2015. Prepared by Umvoto Africa (Pty) Ltd in association with WorleyParsons and UWP Consulting on behalf of the Directorate: National Water Resource Planning.

De Villiers, J. 2018. How Cape Town avoided Day Zero and cut its water usage by 50% in 3 years – it took Melbourne 12 years to do the same. Available: https://www.businessinsider.co.za/how-cape-town-cut-its-water-usage-by-50-in-3-years-it-took-melbourne-12-years-to-do-the-same-2018-3

De Wit, M. & Stankiewicz, J. 2006. Change in Surface Water Supply Across Africa with Predicted Climate Change. Science. 311:1917-1921

Doll, P., Jimenez-Ciseros, B., Oki, T., Arnell, NW., Benito, G., Cogley, JG., Jian, T., Kundzewicz, ZW., Mwakalila, S., Nishijima, A. 2015. Integrating risks of climate change into water management. Hydrological Sciences Journal. 60:1, 4-13. DOI: 10.1080/02626667.2014.967250

Dolnicar, S., Schafer, AI. 2006. Public Perception of desalinated versus recycled water in Australia. 2006 AWWA Desalination Symposium.

Dolnicar, S. and Schäfer, A.I. 2009. Desalinated versus recycled water: public perceptions and profiles of the accepters. Journal of Environmental Management, 90(2), pp.888-900.

Draft Carbon Tax Bill. 2017. Pretoria: Minister of Finance.

Draft Climate Change Bill. 2018. Government Gazette 41689. 08 June 2018. General notice No. R580. Pretoria: Government Printers.

Eamus, D., Froend, R. 2006. Groundwater-dependent ecosystems: the where, what and why of DGE's. Australian Journal of Botany. 54. 91-96.

European Commission. 2013. Green Infrastructure (GI) — Enhancing Europe's Natural Capital. COM(2013) 149.

Environmental Resource Management Department. 2011. Local Action for Biodiversity (LAB), City of Cape Town Biodiversity and Climate Change Assessment Report. City of Cape Town.

European Environmental Agency. 2007. Impacts due to over abstraction. Available: https://www.eea.europa.eu/themes/water/water-resources/impacts-due-to-over-abstraction

Faneca Sanchez, M., Sutanudjaja, E., Kuijper, M. and Bierkens, M. 2016, April. Global Groundwater related Risk Indicators: quantifying groundwater stress and groundwater table decline (1990-2010) at global scale. In EGU General Assembly Conference Abstracts (Vol. 18, p. 16099).

FAO. 2016. AQUASTAT Main Database, Food and Agriculture Organisation of the United Nations (FAO).

Fielding, K. S., Spinks, A., Russell, S., McCrea, R., Stewart, R., & Gardner, J. 2013. An experimental test of voluntary strategies to promote urban water demand management. Journal of environmental management, 114, 343-351.

Fielding, K. S., Dolnicar, S. and Schultz, T. 2018. Public acceptance of recycled water. International Journal of Water Resources Development. 1-36.

Financial Times. 2018. Cape Town's water crisis should be a wake-up call. Available: https://www.ft.com/content/2168dcaa-028a-11e8-9650-9c0ad2d7c5b5

Foxon, T. J. 2002. Technological and institutional 'lock-in' as a barrier to sustainable innovation. Imperial College Centre for Policy and Technology Working Paper.

Fritzmann, C., Löwenberg, J., Wintgens, T. and Melin, T., 2007. State-of-the-art of reverse osmosis desalination. Desalination, 216(1-3), pp.1-76

Geller, ES., Erickosn, JB., & Buttram, BA. 1983. Attempts to Promote Residential Water Conservation with Educational, Behavioural and Engineering Strategies. Population and Environment. 6(2): 96-112

Gilll, S.E., Handley, J.F., Ennos, A.R. & Pauleit, S. 2007. Adapting Cities for Climate Change: The Role of Green Infrastructure. Built Environment. 33(1): 115-133. DOI: http://dx.doi.org.ezproxy.uct.ac.za/10.2148/benv.33.1.115

Given, L.M. 2008. The SAGE encyclopaedia of research methods. Thousan Oaks, CA: SAGE Publications Ltd. Doi: 10.4135/9781412963909

Global Water Partnership. Water Demand Management: The Mediterranean Experience. Technical Focus Paper

Gomez, D., Gonzalez-Arganguena, E., Manuel, C., Owen, G., del Pozo, M., tejada, J. 2003. Centrality and Power in Social Networks: a game theoretic approach. Mathematical Social Science. 46(1): 27-54

Gosling, M. 2018a. City of Cape Town calls for relaxing of water restrictions as dam levels rise. News24. Available: https://www.news24.com/SouthAfrica/News/city-of-cape-town-calls-for-relaxing-of-water-restrictions-as-dam-levels-rise-20180827

Gosling, M. 2018b. Cape Town dams filling up, but drought not broke. News 24. Available: https://www.news24.com/SouthAfrica/News/cape-town-dams-filling-up-but-drought-not-broken-20180625

Gosling, M. 2018c. Sewage keeps taps running in Beaufort West. News 24. Available: https://www.news24.com/SouthAfrica/News/sewage-keeps-taps-running-in-beaufort-west-20180820

Grafton, R.Q., 2005. Social capital and fisheries governance. Ocean & Coastal Management, 48(9-10), pp.753-766.Gray, D.B. 1985. Ecological beliefs and behaviours. London: Greenwood Press.

Green, TR., Taniguchi, M., Kooi, H., Gurdak, JJ., Allen, DM., Hiscock, KM., Treidel, H., Aureli, A. 2010. Beneath the surface of global change: Impacts of climate change on groundwater. Journal of Hydrology (405), 532-560.

GreenCape. 2018. Water – 2018 market intelligence report. Available: https://www.westerncape.gov.za/110green/files/atoms/files/GreenCape-Water-MIR%202018.pdf

Griebler, C., Avramov, M. and Hose, G. 2019. Groundwater Ecosystems and Their Services: Current Status and Potential Risks. In Atlas of Ecosystem Services (pp. 197-203). Springer, Cham.

Gronovetter, M. 1983. The strength of weak ties: A network theory revisited. Sociological Theory. 1: 201-233.

Gronovetter, M. 1973. The strength of weak ties. American Journal of Sociology. 78(6): 1360-1380.

Gross, D.A. 2016. Recycling Sewage into drinking water is no big deal. They've been doing it in Namibia for 50 years. Public Radio International. Available: https://www.pri.org/stories/2016-12-15/recycling-sewage-drinking-water-no-big-deal-theyve-been-doing-it-namibia-50-years

Gude, V.G. 2016. Desalination and sustainability–an appraisal and current perspective. Water research, 89, pp.87-106.

Gude, V.G. 2017. Desalination and water reuse to address global water scarcity. Reviews in Environmental Science and Bio/Technology, 16(4), pp.591-609.

Hallegatte, S., 2009. Strategies to adapt to an uncertain climate change. Global environmental change, 19(2), pp.240-247.

Hanneman, R.A., Riddle, M. 2014. Concepts and measures for basic social network analysis. In The SAGE Handbook of Social Network Analysis. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781446294413

Hart, H.L.A. (1961) The Concept of Law. Oxford: Oxford University Press.

Haunss, S. 2016. Core Network Analytical Concepts [Lecture]. University of Cape Town. 10 May.

Haythornthwaite, C. 1996. Social Network Analysis: An Approach and Technique for the Study of Information Exchange. LISR. 18: 323-342.

Hedden, S. 2016. Parched prospects II-a revised long-term water supply and demand forecast for South Africa. Institute for Security Studies Papers, 2016(16), 18-18.

Helm, D. 2010. Government failure, rent-seeking, and capture: the design of climate change policy. Oxford Review of Economic Policy, 26(2), pp.182-196.

Hendricks, A., Gontsana, MA. 2018. What Cape Town City Councillors are Doing to Help Solve the Water Crisis. Huffington Post. Available: https://www.huffingtonpost.co.za/2018/02/12/what-cape-town-city-councillors-are-doing-to-help-solve-the-water-crisis_a_23358974/

Howlett, M. 2014. Why are policy innovations rare and so often negative? Blame avoidance and problem denial in climate change policy-making. Global Environmental Change, 29, pp.395-403.

Huffington Post. 2017. Cape Town to Cut Free Water Scheme to Combat Drought. *Staff Reporter*. Online: https://www.huffingtonpost.co.za/2017/03/30/cape-town-to-cut-free-water-scheme-to-combat-drought_a_22018117/

Hulme, M., Doherty, R., Ngara, T., New, M., Lister, D. 2001. African climate change: 1900-2100. Climate Research. 33: 145-168.

Hurlimann, A., & Dolnicar, S.(2009). When public opposition defeats alternative water projects - The case of Toowoomba Australia. Water Research, 44(1), 287–297.

ICLEI-Africa. 2012. Building Climate Resilience. Retrofitting as an Adaptation option for the City of Cape Town, South Africa. Josefsson J., Stephen V., & Fairhurst, L. Ed.

Ibarra, H. & Andrews, S.B. 1993. Power, Social Influence, and Sense Making: Effects of Network Centrality and Proximity on Employee Perceptions. Administrative Science Quarterly. 38(2) 277-303. Available: http://www.jstor.org/stable/2393414

IPCC. 2013. Technical summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC. 2014. Summary for Policymakers. In: Climate Change 2014, Mitigation of climate change. Contribution of working group III to Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC. 2007: Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L.

Johnson, R.B. and Onwuegbuzie, A.J., 2004. Mixed methods research: A research paradigm whose time has come. Educational researcher, 33(7), pp.14-26.

Jones, A. 2018. How Cape Town more than halved its water usage. Prepared by Groundup for The Daily Maverick. Available: https://www.dailymaverick.co.za/article/2018-03-13-groundup-how-cape-town-more-than-halved-its-water-usage/#.WvtDsoiFPIV

Jupp, V. 2006. The SAGE dictionary of social research methods. London, SAGE Publications Ltd doi: 10.4135/9780857020116

Kempe, D., Kleinberg, J., Tardos, E. 2015. Maximising the spread of influence through a social network. Theory of computing. 11(4): 105-147. Available: http://www.cims.nyu.edu/~regev/toc/articles/v011a004/v011a004.pdf

Koch, I.C., Vogel, C. and Patel, Z. 2007. Institutional dynamics and climate change adaptation in South Africa. Mitigation and Adaptation Strategies for Global Change, 12(8), pp.1323-1339.

Klitkou, A., Bolwig, S., Hansen, T., Wessberg, N. 2015. The role of lock-in mechanisms in transition processes: The case of energy for road transport. Environmental Innovation and Societal Transitions (16), 22-37.

Knoke, D. 2014. Policy Networks. In The SAGE Handbook of Social Network Analysis. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781446294413

Kollmuss, A., Agyeman, J. 2002. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behaviour? Environmental Education Research 8(3), 239-260. DOI: 10.1080/13504620220145401

Könnölä, T., Unruh, G.C. and Carrillo-Hermosilla, J. 2006. Prospective voluntary agreements for escaping techno-institutional lock-in. Ecological Economics, 57(2), pp.239-252.

Kundzewicz, ZW., MATA, LJ., Arnell, WN., Doll, P., Jimenez, B., Miller, K., Oki, T., Sen, Z., Shiklomanov, I. 2008. The implications of projected climate change for freshwater resources and their management. Hydrological Sciences Journal (53)1, 3-10.

Kusangaya, S. Warburton, ML. van Garderen, EA. & Jewitt, GPW. 2013. Impacts of Climate Change on Water Resources in Southern Africa: A review. Physics and Chemistry of the Earth. 67-69 (2014) 45-54. DOI: http://dx.doi.org/10.1016/j.pce.2013.09.014

Krackhardt, D. 1994. Constraints on the interactive organisation as an ideal type. Networks in the Knowledge Economy. C.Heckscher, A. Donnelon, Eds. Oxford University Press, Oxford. :324-335

Lavrakas, P.J. 2011. Closed-Ended Questions. In: Encyclopaedia of Survey Research Methods. London, SAGE Publications Ltd: DOI: http://dx.doi.org/10.4135/9781412963947

Lee, D.K. & Song, Y. 2019. Urban green infrastructure and the ecological functions. Landscape and Ecological Engineering, pp1-3

Leedy, P. & Ormrod, J.E. 2010. Practical Research – Planning and design. New Jersey, United States of America: Pearson Education.

Leombruni, L.V. 2015. How you talk about climate change matters: A communication network perspective on epistemic skepticism and belief strength. Global environmental change. 35: 148-161

Liao, K. 2019. Dirty sea water brings Cape Town desalination plant to a halt. GroundUp. Available: https://www.groundup.org.za/article/dirty-ocean-water-causes-cape-town-desalination-plant-stop-operating/

Llama, M.R. & Martinez-Santos, P. 2005. Intensive Groundwater Use: Silent Revolution and Potential Source of Social Conflicts. Journal of Water Resources Planning and Management.

McCartney, M. 2009. Living with dams: managing the environmental impacts. Water Policy, 11(S1), pp.121-139.

Magnan, A. 2014. Avoiding maladaptation to climate change: towards guiding principles. SAPIENS 7(1). Available: http://sapiens.revues.org/1680

Margerum, R.D. and Robinson, C.J., 2015. Collaborative partnerships and the challenges for sustainable water management. Current Opinion in Environmental Sustainability, 12, pp.53-58.

Marin, A. & Wellman, B. 2014. Social Network Analysis: An Introduction. In the SAGE Handbook of Social Network Analysis. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781446294413

Matthews, S. 2015. Water reclamation: Water Wheel 14(3), pp. 26-29

Matzikama Municipality. 2012. Integrated Development Plan 2012/2017.

McGray, H., Hammill, A., Bradley, R., Schipper, E., and Parry, J. 2007. Weathering the storm: Options for framing adaptation and development. World Resources Institute. Washington, DC: World Resources Institute.

McIntyre, N. 2012. How will climate change impact fresh water security? The Guardian. 30 November. Available: https://www.theguardian.com/environment/2012/nov/30/climate-change-water [2016, October 4]

McKenzie, R., Siqalaba, ZN., Wegelin, WA. 2012. The state of non-revenue water in South Africa. Water Research Commission. WRC report no. TT 552/12

McPherson, J.M., Ranger-Moore, J.R. 1991. Evolution on a Dancing Landscape: Organizations and Networks in Dynamic Blau Space. Social Forces, 70(1), 19-42. Available: http://links.jstor.org/sici?sici=0037-7732%28 199 109%2970%3A1%3C 19%3AEOADL0%3E2.O.CO%3B2-8

McPherson, J.M., Smith-Lovin, L., Cook, JM. 2001. Birds of a Feather: Homophily in Social Networks. Annual Review of Sociology 27(2001): 415-444. Available: http://www.jstor.org/stable/2678628

Middleton, J., Goldblatt, M., Jakoet, J., Palmer, I. 2011. Environmental Management and Local Government. PDG Occasional Paper No. 1. Prepared by Palmer Development Group (PGD). Available: http://pdg.co.za/wp-content/uploads/2012/04/Environmental-management-and-local-government.pdf

Middelkoop, H., Daamen, K., Gennes, D., Grabs, W., Kwadij, JCJ., Lang, H., Oarmet, BWAH., Schadler, B., et al. 2001. Impact of climate change on hydrological regimes and water resource management in the Rhine Basin. Climate Change (48), 105-128.

Midgley, S.J.E., New, M., Methner, N., Cole, M., Cullis, J., Drimie, S., Dzama, K., Guillot, B., Harper, J., Jack, C. and Johnston, P. 2016. A status quo review of climate change and the agriculture sector of the Western Cape Province. *Report submitted to the Western Cape Department of Agriculture and the Western Cape Department of Environmental Affairs &*

Development Planning. African Climate & Development Initiative, University of Cape Town, Cape Town, South Africa.

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well Being: Synthesis. Island Press, Washington DC.

Mitchley, A., Herman, P. 2018. DA blames national government for exacerbating water shortages. News 24. 29 January 2018. Available: https://www.news24.com/SouthAfrica/News/da-blames-national-government-for-exacerbating-water-shortages-20180129

Mohsen, M.S. and Al-Jayyousi, O.R., 1999. Brackish water desalination: an alternative for water supply enhancement in Jordan. Desalination, 124(1-3), pp.163-174.

Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J., Rivington, M. 2013. Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering climate change impacts. Current Opinion in Environmental Sustainabilty. 5(1) 1-5. DOI: http://dx.doi.org/10.1016/j.cosust.2012.12.001

Naidoo, R. 2017. New regulations could speed up water use licence authorisations. Infrastructure News. 5 June 2017. Available: http://www.infrastructurene.ws/2017/06/05/new-regulations-could-speed-up-water-use-licence-authorisations/

National Environmental Management: Air Quality Act, Act No. 39 of 2004, as amended 2014. Available: https://cer.org.za/wp-content/uploads/2010/03/39-of-2004-NATIONAL-ENVIRONMENTAL-MANAGEMENT-AIR-QUALITY-ACT_-19-May-2014-to-date.pdf

National Water Act, Act No 36 of 1998, as amended 2014. Available: https://cer.org.za/wp-content/uploads/2010/05/36-OF-1998-NATIONAL-WATER-ACT_2-Sep-2014-to-date.pdf

Nelson, R., Howden, M., Smith, M.S. 2008. Using adaptive governance to rethink the way science support Australian drought policy. Environmental Science & Policy, 11, 588-601.

Ngoepe, K. 2015. 5 Provinces Declared Drought Disaster Areas. News 24. 13 November. Available: http://www.news24.com/SouthAfrica/News/5-provinces-declared-drought-disaster-areas-20151113 [2016, October 2]

North, D.C., 1991. Institutions. Journal of economic perspectives, 5(1), pp.97-112.

Pace, A. 2018. Two Cape Town desalination plants go offline. Cape Town etc. Available: https://www.capetownetc.com/water-crisis/two-cape-town-desalination-plants-go-offline/

Pahl-Wostl, C. 2006. Transitions towards adaptive management of water facing climate and global change. Water Resource Management (21), 49-62.

Paluck, EL., Shepherd, H., Aronow, PM. 2016. Changing climate of conflict: A social network experiment in 56 schools. Proceedings of the National Academy of Sciences of the United States of America, 113(3), 566-571. DOI: 10.1073/pnas.1514483113[doi].

Parry, O.F. Canziani, J.P. Palutikof, P.J van der Linder, and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

Park, C. & Allaby, M. 2016. Vulnerability (fragility). In A Dictionary of Environment and Conservation. Oxford University Press. Available: http://www.oxfordreference.com/view/10.1093/acref/9780199641666.001.0001/acref-9780199641666-e-8754 [2016, October 2].

Partridge, A.G. and Wagner, N.J. 2016. Risky business: agricultural insurance in the face of climate change: Elsenburg journal. Agriprobe, 13(3), pp.49-53.

Pasquini, L., Cowling, R.M. & Ziervogel, G. 2013. Facing the heat: Barriers to Mainstreaming Climate Change Adaptation in Local Government in the Western Cape Province, South Africa. Habitat International (40) 225-223. DOI: http://dx.doi.org/10.1016/j.habitatint.2013.05.003

Peter, F., and Spikermann, K. 2011. Rules, norms and commitments. The SAGE handbook of the philosophy of social sciences pp. 217-239. London. SAGE publications Ltd. Doi: 10.4135/9781473913868

Petterson, D. 2016. Driving water savings: municipal insight. IMIESA, 41(11), pp. 12-16.

Porta, M. 2014. A dictionary of epidemiology: Oxford University Press. Available: http://www.oxfordreference.com/view/10.1093/acref/9780199976720.001.0001/acref-9780199976720-e-2021.

Porter, M.G. and Sahin, O. 2016. A Dynamic Water Supply Portfolio Optimisation Approach.

Power, M.E., Dietrich, W.E. and Finlay, J.C. 1996. Dams and downstream aquatic biodiversity: potential food web consequences of hydrologic and geomorphic change. Environmental management, 20(6), pp.887-895.

Primmer, E., Jokinen, P., Blicharska, M., Barton, D.N., Bugter, R. and Potschin, M., 2015. Governance of ecosystem services: a framework for empirical analysis. Ecosystem services, 16, pp.158-166.

Pulido-Velázquez, M., Andreu, J. and Sahuquillo, A. 2006. Economic optimization of conjunctive use of surface water and groundwater at the basin scale. Journal of Water Resources Planning and Management, 132(6), pp.454-467.

Rabe, M., Maree, D. Ramano, R., Price, G. 2012. Compendium of Water Conservation and Water Demand Management Interventions and Measures at the Municipal Level in South

Africa. Report to the Water Research Commission, prepared by Re-Solve Consulting (Pty) Ltd.

Rao, S.V.N., Bhallamudi, S.M., Thandaveswara, B.S. and Mishra, G.C. 2004. Conjunctive use of surface and groundwater for coastal and deltaic systems. Journal of Water Resources Planning and Management, 130(3), pp.255-267.

ReNew Canada. 2009. Adaptation. Available: http://renewcanada.net/2009/adaptation/

Richter, B.D., Postel, S., Revenga, C., Scudder, T., Lehner, B., Churchill, A. and Chow, M. 2010. Lost in development's shadow: the downstream human consequences of dams. Water Alternatives, 3(2).

Riemann, K., Chimboza, N., Fubesi, M. 2012. A proposed groundwater management framework for municipalities in South Africa. Water South Africa (38)3. 445-452.

Rockenbauch, T., and Sakdapolrak, P. 2017. Social networks and the resilience of rural communities in the Global South: a critical review and conceptual reflections. Ecology and Society, 22(1).

Rubin, O., & Dahlberg, R. 2017. Resilience. In A Dictionary of Disaster Management: Oxford University Press. Retrieved 10 Sep. 2019, from https://www.oxfordreference.com/view/10.1093/acref/9780191829895.001.0001/acref-9780191829895-e-170.

Saldanha Bay Municipality. 2017. 4th Generation Integrated Development Plan: 2017-2022.

Saldanha Bay Municipality. 2018. Spatial Development Framework.

SALGA. 2016. The relationship between district and local municipalities and reporting mechanisms. Available: https://www.salga.org.za/Documents/NMMF%202016/Reporting%20between%20Districts%20and%20Locals.pdf

Scarborough, H., Sahin, O., Porter, M. and Stewart, R. 2015. Long-term water supply planning in an Australian coastal city: Dams or desalination?. Desalination, 358, pp.61-68.

Scott, D., and Willits, F.K. 1994. Environmental Attitudes and Behavior. A Pennsylvania Survey. Environment and Behavior 26(2) pp.239-260. SAGE publications.

Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N.W., Clark, D.B., Dankers, R., Eisner, S., Fekete, B.M., Colón-González, F.J. and Gosling, S.N. 2014. Multimodel assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences, 111(9), pp.3245-3250.

Shahzad, M.W., Burhan, M., Ang, L. and Ng, K.C. 2017. Energy-water-environment nexus underpinning future desalination sustainability. Desalination, 413, pp.52-64.

Simonet, G. 2010. The concept of adaptation: Interdisciplinary scope and involvement in climate change. SAPIENS 3(1). Available: http://sapiens.revues.org/997

Smit, B and Wandel, J. 2006. Adaptation, adaptive capacity, and vulnerability. Global Environmental Change 16: 282-292.

South African Government, n,d. Water and Sanitation. Available: http://www.gov.za/about-SA/water-affairs

Spatial Planning and Land Use Management Act, No 16 of 2013. Available: https://www.acts.co.za/spatial-planning-and-land-use-management-act-2013/spatial_planning_and_land_use_

Spence, A., Poortinga, W., Butler, C., Pidgeon, F. 2011. Perceptions of climate change and willingness to save energy related to flood experience. Nature Climate Change, 1(1), p.46

Specter, E.P. 2011. Social Desirability Bias. In The SAGE Handbook of Social Science Research Methods. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781412950589

State of drought disaster declared in 8 provinces. 2016. News 24. 9 June. Available: http://www.news24.com/SouthAfrica/News/state-of-drought-disaster-declared-in-8-provinces-20160609 [2016, October 2]

Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (eds). Cambridge University Press. Cambridge, UK and New York, USA.

Suvedi, M., Krueger, D., Shrestha, A., Bettinghouse, D. 2000. Michigan Citizens' knowledge and perceptions about groundwater. Journal of Environmental Education (31)2, 16-21. DOI: 10.1080/00958960009598634

Swartland Municipality. 2018. Revisions to the Integrated Development Plan for 2017-2022 [Draft].

Syme, GJ., Nancarrow, BE., Seligman, C. 2000. The Evaluation of Information Campaigns to Promote Voluntary Household Water Conservation. Evaluation Review 24(6). 539-578

Tancot, G. 2014. Membrane Bioreactor solves Malmsbury's water challenges. Infrastructure news and Service Delivery. Available: http://www.infrastructurene.ws/2014/03/31/membrane-bioreactor-solves-malmesburys-water-challenges/

Taylor, R.G., Scanlon, B., Döll, P., Rodell, M., Van Beek, R., Wada, Y., Longuevergne, L., Leblanc, M., Famiglietti, J.S., Edmunds, M. and Konikow, L., 2013. Ground water and climate change. Nature Climate Change, 3(4), p.322. http://dx.doi.org/10.1038/nclimate1744 (2012)

Thopil, G.A. & Pouris, A. 2016. A 20 year forecast of water usage in electricity generation for South Africa amidst water scarce conditions. Renewable and Sustainable Energy Reviews. 62: 1106-1121. DOI: http://dx.doi.org/10.1016/j.rser.2016.05.003

Tongco, M.D.C. 2007. Purposive sampling as a tool for information selection. Ethnobotany Research and Applications, 5, pp. 147-158.

Traugott, M.W. 2011. Closed Ended Questions. In: The SAGE Encyclopaedia of Social Science Research Methods. Ed. Lewis-Beck, MS., Bryman A., Liao, T.F. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781412950589

Uhlmann, V., & Head, B. W.(2011). Water recycling: Recent history of local government initiatives in South East Queensland: Urban Water Security Research Alliance Technical Report No. 45.

United Nations Framework Convention on Climate Change (UNFCCC). 2006. Technologies for Adaptation to Climate Change. Peter Stalker, Ed. Bonn, Germany. UNON Publishing.

United Nations Water. 2010. Climate Change Adaptation: The Pivotal Role of Water. Policy Brief. Available: http://www.unwater.org/publications/publications-detail/en/c/206477/

United States Environmental Protection Agency. 2018. Stormwater management and green infrastructure research. Available: https://www.epa.gov/water-research/stormwater-management-and-green-infrastructure-research

Van der Linden, S. 2015. The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. Journal of Environmental Psychology, 41, pp.112-124.

Van Jaarsveld, A.S. & Chown, S.L. 2001. Climate Change and it's impacts in South Africa. Research Update. Trends in Ecology & Evolution. 16(1) 13-14.

Veolia. 2015. Desalination plant resolves holiday town's water crisis. Available: http://www.veoliawatertechnologies.co.za/medias/news/2015-02-18,desalination-plant-is-constant-water-source.htm

Visser, M., Marthinus J.B., Berger, K., & Brühl. J. 2019. Saving Water at Cape Town Schools by Using Smart Metering and Behavioural Change. engrXiv. July 17. doi:10.31224/osf.io/7kzwv

Vogt, W.P. 2011. Social Desirability Bias. In Dictionary of Statistics & Methodology. London, SAGE Publications Ltd. DOI: http://dx.doi.org/10.4135/9781412983907

Vörösmarty, C.J., Green, P., Salisbury, J. and Lammers, R.B., 2000. Global water resources: vulnerability from climate change and population growth. science, 289(5477), pp.284-288.

Wang, X.J., Zhang, J.Y., Shahid, S., Guan, E.H., Wu, Y.X., Gao, J. and He, R.M. 2016. Adaptation to climate change impacts on water demand. Mitigation and Adaptation Strategies for Global Change, 21(1), pp.81-99.

Western Cape Government. 2013a. Bergrivier Local Municipality: Overview. Available: https://www.westerncape.gov.za/your_gov/3

Western Cape Government. 2013b. West Coast District Municipality: Overview. Available: https://www.westerncape.gov.za/your_gov/29

Western Cape Government. 2014. Western Cape Provincial Spatial Development Framework. Cape Town: Government Printers.

Western Cape Government. 2014. Western Cape Climate Change Response Strategy. Available: https://www.westerncape.gov.za/text/2015/march/western_cape_climate_change_response_strategy_2014.pdf. Cape Town: Government Printers.

Western Cape Government. 2018. Bitterfontein e-Centre: About Bitterfontein. Available: https://www.westerncape.gov.za/capeaccess/e-centres/West-Coast-District/Bitterfontein/about-us

West Coast District Municipality. 2019. Integrated Development Plan 2017 – 2022 Review 2. Available: http://westcoastdm.co.za/wp-content/uploads/2019/06/290519WCDM-IDP-2017-2022-Review-2-FINAL-1.pdf

West Coast District Municipality. 2017. Integrated Development Plan 2017 – 2022. Available: http://westcoastdm.co.za/wp-content/uploads/2017/06/WCDM-IDP-2017-2022-May-2017-Final-document-1.pdf

West Coast District Municipality. 2014. Towards day-to-day resilience: A policy framework for climate change response in the west coast district. Prepared by Aurecon South Africa. Available: http://westcoastdm.co.za/wp-content/uploads/2016/06/WCDM-Climate-Change-Response-Framework-1.pdf

West Coast District Municipality. 2012. Available: http://westcoastdm.co.za/

Whitmarsh, L. 2008. Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. Journal of risk research, 11(3), pp.351-374.

Widd, N., Ziervogel, G. 2012. Adapting to climate change in South Africa: commercial farmers' perception of and response to changing climate. South African Geographical Journal (94) 2, 152-173.

Wilhite, D.A. 2011. Breaking the Hydro-Illogiiical Cycle: Progress or Status Quo for Drought Management in the United States. European Water, 34, 5-18.

Wilhite, D. A. 2012. Breaking the hydro-illogical cycle: Changing the paradigm for drought management. Drought Mitigation Center Faculty Publications. 53. Available: http://digitalcommons.unl.edu/droughtfacpub/53

Williiams, J. 2017. The latest Cape Town dam levels – 21 August 2017. Available: https://www.capetownetc.com/news/cape-town-dam-levels-august-2017/

Winter, K. 2018. Day Zero is meant to cut Cape Town's water use: what is it, and is it working? Available: https://theconversation.com/day-zero-is-meant-to-cut-cape-towns-water-use-what-is-it-and-is-it-working-92055

Wolski, P. 2018. Drivers of Cape Town's water shortage. Climate Systems Analysis Group blog post. Available: http://www.csag.uct.ac.za/2018/07/18/drivers-of-cape-town-water-shortage/

Woolcock, M. 1998. Social capital and economic development: Toward a theoretical synthesis and policy framework. Theory and society, 27(2), pp.151-208.

Yang, B., & Li, M-H. 2010. Ecological engineering in a new town development: Drainage design in The Woodlands, Texas. Ecological Engineering, 36 (2010), pp. 1639-1650.

Ziervogel, G., Shal, M. & Du, M. 2010. Climate Change Adaptation in a Developing Country Context: The case of urban water supply in Cape Town. Climate and Development, 2:2, 94-110.

Ziervogel, G., Johnston, P., Matthew, M., Mukheiber, P. 2009. Using climate information for supporting climate change adaptation in water resource management in South Africa. Climate Change, 103(3-4), pp. 537-554. DOI 10.1007/s10584-009-9771-3

Ziervogel, G., Mukheibir, P. 2006. Framework for Adaptation to Climate Change in the City of Cape Town (FAC4T). Cape Town, Department of Environmental Resource Management.

Appendices

Appendix 1 – Interview Guide

Component	Parameter	Questions	Outcome
Views and Behaviours	Views	In your view, what is the best way to reduce consumption or demand of water in your municipality? - Why do you feel that (methods/tools mentioned to reduce consumption) is the best way to reduce consumption/demand?	Identification of the actor's views on water demand management.
		In your view, what is the best way to increase the available supply of water in your municipality's water system? - Why do you feel that (the methods mentioned) assist, or are the best solution to increasing supply?	Identification of the actor's views on water supply management.

		What does climate change (OR global warming) mean to you?
		- 1) What role do you feel climate change has on the water supply (and demand) system at the municipal level?
		  o Why?
		- 2) (if CC denialist) What do you feel is the biggest threat to the water supply system (or increasing demand) of your municipality?
		  o Why do you feel (x/y/z) is such a threat?
			Identification of the actor's views regarding climate change adaptation.

		What does the term “adaptation” mean to you?
		
		- How do you see adaptation playing a role in alleviating stress on the water supply system by either decreasing demand, or increasing supply?
		- (do not see a role for it) What method do you feel is the most effective in reducing stress on the water supply system?
		  ○ Do you feel this method is the most sustainable (explain sustainability)?
		  ▪ Why?	

	Behaviours	In the situation where the municipality is facing a loss of water supply due to lack of rainfall, and needs to ensure that the available supply lasts for as long as possible, how would you go about decreasing demand or perhaps increasing supply? Can you give three examples? Why would you make these changes/decisions?	Identifying the actor’s responses to a water stressed environment and how to manage it.
	Behaviours	Climate change is expected to have impacts on the hydrological cycle, and in areas such as the West Coast of the Western Cape, this may result in increased drought conditions and flood events. Considering these predictions, how would you approach adapting the water supply system to be able to provide sufficient water for the population living within the municipality? i.e. what sorts of adaptation measures would you put in place to either enhance supply, or reduce demand. Why would you put these measures in place? Do you currently have CC considerations in your work?	Identification of the actors approach to adapting the water supply and demand system for the impacts of climate change. Gives sense of barriers

		- If no: Why?	
Norms (ask in conjunction with ties)	Injunctive norms	Within the five main individuals you interact with, do you seek their approval when making a decision regarding municipal water management?	Identifying the actors norms with regards to their social network and what is normal within the network.
	Descriptive norms	With regards to the examples given on increasing supply or decreasing demand of water supply, do you find that the typical decisions made within the municipality are aligned with these?	
Social Network ties	Social Ties (links with norms and reference group)	Who are the five main individuals you consult with for information related to water management? (can be from anywhere) - Do these people add other forms of support outside of water management? If less than 5, then continue with questions SN characteristics (Backup) – Think of 5 people you depend on the most to carry out your job successfully.	Identification of actors in the social networks of respondent.
	Homophilly	Of the five people you interact with, do you feel they share the same values and views as yourself with regards to climate change adaptation and water resources?	Determining if the actors within the social network share the same views and norms as the respondent

		Ask for views tie by tie, be specific on CC and water management. Why do you feel they may be similar or different than your values and views?	
	Nature of ties / social capital	For each of the individuals you interact with, are they in the same municipality? The same department? A different level of government? An outside organisation? What position do they hold? (can use pseudonym)	Identification of the types of ties held by respondents (Bonding/bridging/linking ties)
Tie Strength	Reliance	How reliant (explain) are you on each individual in your network? How would you rank these individuals on a scale of 1-5 in terms of reliance on them for information regarding adaption and water resource management? Where 1 is a person you rarely ask for information and 5 is a person you rely on heavily for information and guidance. Can you tell me why you rank said person as a 1, 2, 3, 4, or 5?	Identification of importance of ties for providing information to respondent / measure of strength of tie
	Frequency of interaction	How frequently do you interact with each person? Is it every day, once a week, once a month, every six months, or once a year?	Identification of actors who share frequent interactions with the respondent
	Intimacy	What would you say the nature of the relationship is between yourself and each of the 5 people you interact the most with is? On a scale of 1-5,, where 1 means your relationship with the person is purely professional, and 5 means that you are very close to that person, feeling they are close friends or family. Is there conflict (disagreement) with these individuals? Could you rank how much conflict there is? With 1 being no conflict (full agreement) and 5 being complete disagreement (full conflict).	Identification of emotional closeness of actors with respondent.

Appendix 2 – Ethical Clearance Obtained from the Faculty of Science (University of Cape Town)

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

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18 November 2016

Kristian Gerstnek
African Climate and Development Initiative

Social Networks and Influence in Climate Change Adaptation: The case of municipal water management

Dear Kristian Gerstnek

I am pleased to inform you that the Faculty of Science Research Ethics Committee has approved the above-named application for research ethics clearance, subject to the conditions listed below.

- Implement the measures described in your application to ensure that the process of your research is ethically sound; and
- Uphold ethical principles throughout all stages of the research, responding appropriately to unanticipated issues: please contact me if you need advice on ethical issues that arise.

Your approval code is: **FSREC 068 – 2016**

I wish you success in your research.

Yours sincerely

signature removed to avoid exposure on line

Prof Timm Hoffman
Chair: Faculty of Science Research Ethics Committee

Cc: Dr Lorena Pasquini (Supervisor)

Appendix 3 – Copy of informed voluntary consent letter to participate in study

African Climate & Development Initiative

GEOLOGICAL SCIENCE BUILDING,
UNIVERSITY OF CAPE TOWN
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RONDEBOSCH 7701
SOUTH AFRICA

RESEARCHERS: Kristian Gerstner, Lorena Pasquini

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Informed Voluntary Consent to Participate in Research Study

Project Title: Social Networks and Influence in Climate Change Adaptation: The case of municipal water management

Invitation to participate and benefits: You are invited to participate in a research study conducted by a MPhil student from the African Climate & Development Initiative (ACDI) of the University of Cape Town, researching the impact social network characteristics have on the spread of norms and views on water management at a local municipal level. I believe that your experience would be a valuable source of information, and hope that by participating you may gain useful knowledge.

Procedures: During this study, you will be asked to engage in a discussion around a set of open questions. These questions will focus around your views on water management and focus specifically on measures around adapting to a water stressed scenario as a result of climate change.

Risks: There is no foreseeable risk to your person or to your institution as a result of partaking in this study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name unless you specifically agree on that.

What signing this form means:

By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I agree to participate in this research (tick one box)

☐ Yes ☐ No _____ (Initials)

Name of Participant	Signature of Participant	Date
Name of Researcher	Signature of Researcher	Date