Climate Resilience Planning in the City of Johannesburg

Muhammad Jassat

A dissertation submitted to the Faculty of Science, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science

Johannesburg, 2021

Supervised by Dr Ute Schwaibold

Co-Supervised by Professor Coleen Vogel

Declaration

I declare that this dissertation is my own, unaided work. It is being submitted for the Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

_____

Signature

22 day of October 2021 in

Pretoria

Abstract

We live in an unpredictable world, with climate change and events like Covid-19 exacerbating this unpredictability. Climate change has affected service delivery in many parts of the world, with extreme weather events affecting energy, water, and food security. Planners globally are utilising concepts like resilience in order to prepare for the uncertainty of the world we live in. Whilst there is a growing body of literature on resilience, at the policy creation and implementation level there is a lack of clarity regarding what resilience means, except that it is 'good' to be resilient. This study makes use of the Rockefeller Foundation's definition of resilience, as it was developed for the local City context.

The aim of this study is to assess to what extent the City of Johannesburg (CoJ) embeds climate change resilience planning and relevant resilience implementation into City policy. The study also assesses the manner in which climate resilience is embedded in water management policy, as water is regarded as a fundamental link between the climate system, environment and human society. A scorecard was developed by utilising the principles of resilience as understood by the Stockholm Resilience Centre amongst others. This scorecard was used to assess the City's strategic documents, as well as its water management policies. A series of interviews also took place to determine whether climate resilience is understood by CoJ officials and if there are any climate resilience projects being implemented in the CoJ.

Resilience became a part of the planning discourse in the CoJ during the development of the *GDS 2040* and the word resilience was widely used in policy subsequently. This study found that, while the CoJ's strategic policy documents incorporated climate resilience planning, the City does not holistically consider climate change or the environment. The CoJ's water management policy landscape considers climate resilience planning; however, this was not by design for the most part, as most of the water management policies assessed by this study were promulgated before resilience became part of the planning discourse in the City. The study found that the 'Policy by the way' concept can potentially have a positive effect on the holistic embedding of the principles of climate change resilience in policy development. Mainstreaming of resilience planning principles are crucial for developing a resilient city, and education can play a major role in the mainstreaming of resilience.

Key words: Climate change resilience; Resilience; Sustainable development; Redundancy; Diversity; Feedback loops; Polycentric; Adaptive governance

Acknowledgement

I would like to thank my supervisor's Dr Ute Schwaibold and Professor Coleen Vogel. Their assistance has been most valuable. Thank you for the insights and motivating me. I would also like to thank Professor Francesca Parrini and Professor Mulala Simatele for serving as my committee members and providing me with valuable input into this project

I would also like to thank my family and friends. Your love and encouragement have meant the world to me and thank you for never giving up on me and for not letting me give up on myself.

For those that assisted me in acquiring the necessary information and volunteering their time to be interviewed, your input was invaluable and for that you have my utmost gratitude. A big thank you goes to the City of Johannesburg, for allowing me to interview officials and the Environment Services and Infrastructure Department who opened up their archives to me and provided me with so much invaluable information. I would also like to thank Ms. Lebo Molefe who gave me the opportunity to gain valuable work experience through the City of Johannesburg's internship program.

Contents

List of Tables and Figures

This Page Left Blank

Chapter 1: Introduction and Rationale

Climate change is regarded as one of the most challenging global issues of our time with acknowledgment that anthropogenic greenhouse gas emissions are a major driving cause of this change (Collins *et al*., 2013). Climate change has already had observable effects on the environment, for example plant and animal ranges are shifting, glaciers are shrinking, sea levels are rising and there are longer and more intense heat waves and other extreme events (Collins *et al*., 2013).

The effects of climate change that are occurring now have provided proof that climate change is real, and that immediate action is needed (Mann *et al*., 2017). Globally governments are aware of the risks of climate change and have developed and implemented strategies and plans to deal with these risks (Bulkeley, 2013; Collins *et al*., 2013). These strategies and plans utilise concepts like adaptation, mitigation, sustainable development and more recently climate resilience planning (West *et al*., 2009).

South Africa, like the rest of the world is affected by climate change and climate variability; impacts include water scarcity, heat waves and severe storm events (Theeboom *et al*., 2009; Engelbrecht *et al*., 2015; Hoegh-Guldberg *et al*., 2019). These impacts have brought some benefits but have generally been detrimental to the South African economy and its society (Theeboom *et al*., 2009; Davis and Vincent, 2017). Johannesburg, for example, a major metropolitan area in South Africa with an estimated five million inhabitants, has been affected by water restrictions and storms, including tornados (CoJ, 2016a; Global Change Institute, 2018). The effects of climate change at a country level have made government aware of the risks of climate change and climate variability and like their global counterparts, the South African government has developed strategies and plans to deal with these risks (Perine and Keuck, 2018; DEA, 2020; CoJ, 2021).

Climate change strategies and plans utilise concepts like climate resilience, adaptation, mitigation, and sustainable development (Perine and Keuck, 2018). The aim of Sustainable Development efforts is designed to reduce or eliminate environmental impact and improve the quality of life. Climate resiliency is aimed at enhancing and developing socio-ecological systems that can endure climate shocks or stresses (Marchese *et al.*, 2018). Finally, adaptation refers to adapting to climate change that has already occurred while mitigation

refers to the reduction and stabilization of greenhouse gas emissions (Perine and Keuck, 2018).

Climate resilience planning has emerged in recent years as a holistic alternative to sustainable development and adaptation (Tyler and Moench, 2012). This shift is reflected by global initiatives like the Rockefeller Foundation's 100 Resilient Cities initiative, as well as the growing number of publications on climate resilience planning (Woodruff *et al.,* 2018). Climate resilience planning encompasses both mitigation and adaptation and goes beyond the two concepts as it seeks to build a country or organisation that is more proactive and better prepared to recover from climate related disasters (Tyler and Moench, 2012).

While sustainable development and climate resilience are considered to be distinct concepts in planning discourse, the similarities between sustainable development and climate resilience results in these concepts often being used without clear distinction in meaning, understanding and purpose (Marchese *et al.,* 2018). It is important to note that resiliency and sustainable development both focus on the state of a system, specifically on the persistence of a system in the face of disturbances (Fiksel *et al.,* 2014; Marchese *et al.,* 2018). This joint focus on system survivability, results in resilience and sustainable development usually sharing similar research methodologies and frameworks (Bocchini *et al.,* 2014; Marchese *et al.,* 2018).

The rapidly growing body of research on climate resilience has prompted a variety of attributes or principles that are important to building climate resilience in socio-ecological systems (Biggs *et al*., 2015). The most commonly identified principles are the capacity to learn, redundancy, diversity, self-sufficiency and connectedness, managing slow variables and feedbacks, broadening participation and promoting polycentric and adaptive governance (Harrison *et al*., 2014; Morecroft *et al*., 2012; Biggs *et al*., 2015).

The principles that underpin climate resilience planning have been part of planning discourse within various frameworks prior to the rise of climate resilience planning within planning literature (Biggs *et al*., 2015). Polycentric governance, for example, is a governance system in which there are several governing bodies interacting to create and enforce rules within a certain policy area or location has been part of planning discourse since the 1960s (Ostrom *et al.,* 1961; Carlisle and Gruby, 2018).

Resilience planning has thus gained a central place in spatial planning globally, and in City of Johannesburg (CoJ) this has been no different. The concept of resilience gained prominence in the CoJ's planning discourse during the development of the Growth and Development Strategy 2040 (Peyroux, 2015). Researchers from the South African Cities Network (SACN) consider the CoJ to have what they describe as an 'emerging climate resilience system' (SACN, 2014: p. 3). 'Emerging' indicates that while climate change resilience is discussed in long-term planning documents there is no indication that there is integration and implementation of climate change resilience initiatives in the CoJ (SACN, 2014). It should be noted that the SACN study was conducted in 2014 and the situation may have changed in the last five years.

1.1 Significance of this study

Cities are both a challenge and an opportunity in the fight against climate change. Cities are hubs of economic and social activity and also generate the bulk of the world's greenhouse gas emissions (C40, 2021). Furthermore, the concentration of socio-economic activity, infrastructure and people within cities translates into a significant vulnerability to climate change (Bai *et al.*, 2018). The density of people within cities provides an opportunity to reducing greenhouse gas (GHG) emissions, for example mass transport can provide significant GHG emissions reductions (OECD, 2013). Mass transport is not viable in areas where population densities are below certain thresholds. Therefore, the need for cities to have designed and implemented effective climate resiliency policy is paramount (Bai *et al.*, 2018; Bellinson and Chu, 2019).

Governance and government actions also influence the framing of how actions on climate resilience are undertaken (Bromley-Trujillo and Holman, 2020). Changing political outcomes have had a direct impact on how the CoJ interacts and frames climate change efforts. These political dimensions are covered in more detail in section 2.8. The change in government that occurred, from the African National Congress to a Democratic Alliance led coalition, in the CoJ in the August 2016 local government elections provided this study with an opportunity to evaluate the impact of a change in government (Lodge, 2020). Specifically, an opportunity to evaluate the impact of political change on climate resilience planning.

1.2 Research aim and objectives

The aim of this study is to assess to what extent the City of Johannesburg embeds climate change resilience planning and relevant resilience implementation in City policy using a focus on the water sector.

The objectives of this study include:

1. To examine the CoJ's key strategic documents which shape policy and planning in the City to determine whether climate change resilience is a focus of attention;
2. To examine the extent to which climate change resilience planning is considered in the water sector; and
3. To interview senior city officials to probe to what extent, if at all, climate change resilience planning is implemented in the CoJ.

1.3 Scope of this study

Resilience, as indicated above, has a wide and varying discourse that underpins how the concept of resilience is framed and implemented. The first part of this study thus explores the manner in which the concept of resilience and its application in building a country, province or municipality that is resilient to climate change is beginning to be understood. The literature review also provides a baseline against which one can begin to appraise the 'state' of resilience planning in the City. As is illustrated in section 2.7, the concept of resilience gained prominence in the CoJ's planning discourse, during the development of the *Growth and Development Strategy 2040* in 2011 (Peyroux, 2015**).**

Using content analysis, the second part of this study examines the manner in which the City of Johannesburg embeds climate resilience planning into its policies, strategies, and plans. This study assesses the CoJ's key strategic documents which in the context of this document is the *Growth Development Strategy* (GDS) *2040* and the *Integrated Development Plan* (IDP) *2016-21* and the *IDP 17/18 Review*. Furthermore, a deeper assessment was undertaken into one of the key service delivery areas that is affected by climate change, namely water. That is water in all its dimensions, including the management of water as a resource and as a climate

risk to the CoJ (floods and droughts). Water was investigated because it is a fundamental link between the climate system, environment, and human society (OECD, 2013; Romero-Lankao *et al.,* 2017).

1.4 Layout of the dissertation

Following on the above introduction, attention turns to the outline of the dissertation and what is contained in each Chapter. Chapter one has introduced the study, its significance, scope and the research aim and objectives. Chapter two provides a literature review to expand on chapter one and to contextualise the study. Chapter three provides the methodology that was used. Chapter four presents the results and finally chapter five discusses the findings and critically assesses what this means for the City of Johannesburg and climate resilience planning. The study concludes with Chapter six which discusses the limitations to the study, direction of future studies and concluding remarks. Finally, a reference list accounts for the literature cited in this dissertation and is followed by several appendixes for all of the chapters.

Chapter 2: Background and literature review

This chapter contextualizes the emergence of climate resilience planning in the available literature. Climate resilience planning is examined practically by interrogating the principles that underpin climate resilience planning and by presenting several case studies of climate resilience planning. Initially resilience themes are described, and the focus progressively narrows to the core issues that this study seeks to address, namely climate change resilient planning in the City of Johannesburg, both at the strategic level and at the sectoral level (water management). This focus is designed to better understand the function and utility of notions of resilience in guiding climate planning in cities.

2.1 The emergence of climate resilience planning

Resilience planning has emerged in recent years as the next phase of sustainable development to provide new perspectives on development in a changing world (Leichenko, 2011). In recent years, the concept has gained a central place in spatial planning, both globally and in South Africa (Harrison *et al*., 2014) with a specific focus on climate change and disaster risk reduction (Davoudi *et al.*, 2012). Whilst the concept of resilience is widely used in policy, resilience is not used in a defined and exact way but rather, as an umbrella term which is used, relatively loosely to express several of the conceptual underpinnings of the wider climate change adaptation approach (Davoudi *et al.*, 2012). The use of resilience in policy, can, however, be related to the various definitions of resilience as understood by resilience literature, particularly resilience as understood by ecological and social science (Holling, 1973; Davoudi et al., 2012; Harrison et al., 2014). Resilience, for example, has been defined as *"the ability of a system to absorb disturbances and still retain its basic function and structure"* (Walker and Salt, 2006: p. 1) amongst several other definitions which will be explored in this chapter.

There is a common misunderstanding that climate resilience has replaced sustainable development or that the two concepts are the same (Fiksel, 2006; Ahern, 2011). Whilst resilience and sustainable development are conceptually linked, they differ in meaning. Sustainable development intends to reduce or eliminate environmental impact and improve quality of life while climate resiliency intends to develop socio-ecological systems that can

endure climate shocks or stresses (Marchese *et al.,* 2018). These two concepts can co-exist if sustainable development is treated as an essential goal of development, and climate resilience planning is treated as a way of planning that will lead to sustainable development (Ahern, 2011). Thus, resilience is regarded as a key component to sustainable development by some authors (Fiksel, 2006; Ahern, 2011)

The concept of resilience in the literature has also evolved over the last decade after being integrated into planning literature and social sciences (Davoudi *et al.,* 2012; Taşan –Kok *et al*., 2013). The concept first emerged as an ecological concept, where resilience was defined as the ability of a system to absorb change (Holling, 1973). The concept then emerged in social sciences where resilience was defined as "*the capacity of the system to absorb disturbance*" (Timmerman, 1981: p. 21). Finally, resilience emerged in the urban planning space, where it was defined as "*an adaptive system that adjusts and responds in ways that do not damage or jeopardise effective functioning, remaining on an existing developmental trajectory or making the transition to a new one*" (Hudson, 2010: p. 12).

Resilience also has several disciplinary origins, among them biology, engineering, and psychology (Holling, 1973; Gunderson and Holling, 2003; Taşan –Kok *et al*., 2013). Thus, resilience has a plethora of definitions, however at the system level it is commonly understood as *"the ability of a system to absorb disturbances and still retain its basic function and structure*" (Walker and Salt, 2006: p. 1).

Moving beyond resilience as a concept, the history of resilience as a theory and the fields of study that have influenced resilience thinking have also resulted in a plethora of interpretations and definitions (Davoudi *et al.,* 2012; Taşan –Kok *et al*., 2013). The Rockefeller Foundation, for example, offers a simple definition of resilience in their City Resilience Framework: "*City resilience describes the capacity of cities to function so that people living and working in cities – especially the poor and vulnerable – survive and thrive no matter what shocks and stresses they encounter*" (Rockefeller Foundation and ARUP, 2014: p. 3). This definition of resilience will be employed by this study, as it was developed with a particular local government context (Rockefeller Foundation and ARUP, 2014). This definition encompasses the following: the ability of a system to absorb disturbances (Holling, 1973); and the capability of a system to self-organise and to adapt into a more desirable configuration (Hudson, 2010; Harrison *et al*., 2014; OECD, 2013).

2.2 Principles of resilience planning

Walker and Salt (2006) identified three elements which they thought were critical to resilience planning in general. The first is that humanity is part of a socio-ecological system where human life and nature must never be separated. The second element is that there must be an awareness that a socio-ecological system is complex, and the third element is the willingness of an individual and/or organisation to improve the adaptive capacity of the socio-ecological system through a flexible, collaborative and learning-based approach (Walker and Salt, 2006). These principles were further expanded and built on by several authors, both in the ecological and planning spaces (Davoudi *et al.*, 2012; Taşan –Kok *et al*., 2013). Researchers from various institutes have attempted to identify key principles for building resilience in socio-ecological systems. The most commonly identified principles are: redundancy and diversity; self-sufficiency and connectedness; managing slow variables and feedbacks; broadening participation, promoting polycentric and adaptive governance; and the capacity to learn and innovate (Harrison *et al*., 2014; Biggs *et al*., 2015).

One of the key principles of resilience is redundancy, as redundancy theoretically allows a system to function in perpetuity, as a result of multiple elements providing similar or the same functions, wherein the failure of one of these elements for a period of time will not affect the functioning of the entire system (Ahern, 2011; Simpson *et al.*, 2020). Government's institutional structure should therefore incorporate redundancy and should be designed such that it operates in a decentralised manner, as a centralised command structure is vulnerable to failure if there is a collapse at the highest governance levels. A decentralised system that operates with many autonomously governed units is argued to be less vulnerable to change, however co-operation between these units is essential (Harrison *et al*., 2014; Biggs *et al*., 2015). Additionally, flexibility should be built into the human resource base of government, such that staff have skills that allow them to take on different jobs as the need arises (Harrison *et al*., 2014; Biggs *et al*., 2015). Whilst resilience promotes redundancy most management and planning theory emphasize reducing or eliminating unnecessary redundancies (Streeter, 1992).

The goal of most management theory is to have a streamlined organisation, with the least number of operational units and personnel while still being able to achieve organisational

goals (Streeter, 1992). Resilience theory, however, challenges this view as duplication enables a variety of responses to challenges and provides an important fail safe against system component failure (Biggs *et al*., 2015). Redundancy needs to also be built not just into governance, but also into all aspects of a country, province or city (Biggs *et al*., 2015). An economy, for example, cannot be reliant on just one sector, Saudi Arabia being a case in point where the lack of redundancy in their economy resulted in that country having to curtail spending because of a drop in oil prices (Hamilton, 2009). It is imperative that redundancy is built into the infrastructure of a country, for example, some cities have built redundancy into their water supply by constructing redundant pipe connections and placing valves strategically which allows damaged areas to be temporarily bypassed (Harrison *et al*., 2014).

Diversity is also equally important in local climate change planning and building a resilient system. While redundancy involves several components serving the same function, diversity involves many components performing the same function differently. The more diverse a system, the lower the risk of failure, and there are chances for new lines of development and growth (Harrison *et al*., 2014). For government to be resilient, it would need to have a range of different spatial and temporal responses. This diversity of responses allows for different ways of thinking and doing, spreads risk and increases the chance of successful adaptation to change (Ahern, 2011; Harrison *et al*., 2014).

Socio-ecological systems must also be self-sufficient and connected (Harrison *et al*., 2014). Self-sufficiency and connectedness are concepts that originated in psychology, as psychologists believe that a resilient individual is one that is materially and emotionally self-sufficient to a degree, but also has a network of friends and family that can help in difficult times (Nygren *et al.*, 2005). Therefore, in a similar manner it is necessary for government to be self-sufficient to an extent and be connected to a network simultaneously (Chandra *et al*., 2011). A country, for example, that is isolated either by policy or because of sanctions, is often vulnerable to natural disasters, North Korea being a case in point where droughts caused famine that was exacerbated by sanctions (Haggard and Noland, 2009). Between 1995 and 2000, an estimated one million North Koreans died because of a famine, with sanctions identified as having a notable effect on disaster relief. Sanctions slowed the flow of humanitarian aid into the country and made the purchase of agricultural inputs difficult for

the North Korean government to acquire, which could have mitigated the impact of the drought (Zadeh-Cummings and Harris, 2020).

Although a well-connected system can usually overcome and recover from disturbance quickly, a system that is overly connected may increase the spread of a disturbance across the entire system so that all components of the systems are affected. Thus, a balance needs to be found between connectedness and self-sufficiency (Harrison *et al*., 2014).

A key dimension of resiliency is the issue of feedback loops in the system. Feedbacks occur when outputs of a system are routed back, as inputs as part of a chain of cause-and-effect that forms a loop. A feedback loop can either reinforce or dampen change, i.e., a feedback loop can either be positive or negative (Biggs *et al.,* 2015). Some slow variables and feedbacks can enhance the resilience of a system, for example dampening feedbacks counter the effects of disturbances and change so that the system recovers and keeps working in the same way (Biggs *et al.,* 2015). It is essential for government to strengthen feedbacks that maintain desirable regimes, avoid actions that obscure these feedbacks and monitor important slow variables. Avoiding actions that obscure feedbacks to prevent the masking or distorting of dampening feedbacks is also critical. Strengthening of desirable feedback loops, monitoring of slow variables, and preventing actions that obscure feedback loops require effective governance structures (Gallopin, 2006; Biggs *et al.,* 2015). These structures should be effective in both monitoring and evaluation and in their response strategy (Biggs *et al,.* 2015).

None of these more theoretical aspects of resilience can occur without a focus on the 'human dimensions' of resiliency. Broadening participation in the context of managing a socio-ecological system relates to involving a diversity of stakeholders, which enhances resilience by improving legitimacy, expanding the depth of knowledge and helping to detect perturbations (Reed, 2008; Biggs *et al.,* 2015). Participation can range from informing stakeholders to a devolution of power. Participation can occur at any and/or all stages of a management process, however it occurs primarily in the startup phase as it defines management priorities and needs (Reed, 2008; Biggs *et al.,* 2015).

Socio-ecological systems require collective action, which is why broad and well-functioning participation is essential as it builds trust and a shared understanding of and responsibility for the system. It also uncovers perspectives that may be missed by traditional scientific processes and can strengthen information gathering and decision making (Reeds, 2008).

Broad participation, however, if not undertaken correctly, may result in competition and conflict which can degrade the resilience of a socio-ecological system, as decision-making bodies are paralysed by their inability to reach consensus (Reed, 2008; Biggs *et al.,* 2015). Participation should therefore be carefully managed so that it has a meaningful impact on the management of the socio-ecological system. This can be achieved by establishing clear goals, including the relevant stakeholders for the issue at hand so that potential conflicts and power issues can be addressed. Other influencing factors include having a motivating leader, and securing sufficient resources to enable participation (Reed, 2008; Biggs *et al.,* 2015).

The key to effective resilience planning is arguably governance, as the resiliency of a socio-ecological system can be hamstrung by the lack of effective governance (Plummer, 2012). The resiliency of communities in Bangladesh to water security, for example, was affected by governance failures because of corruption (Lewis, 2017). Climate adaptive governance has been suggested as a measure to improve resilience planning, as the adaptive governance approach allows a system to be managed in a way that improves the understanding of complex components that make up a system (Garmestani and Benson, 2013). Governments, some argue, should manage their country using both active and passive adaptive management techniques (Resilience Alliance, 2010) which involves monitoring of indicators which then feed into a planning, implementation, monitoring and evaluation loop and allow for policy adjustments based on what is learnt (Resilience Alliance, 2010). Active adaptation management utilises tailored management interventions to test hypotheses by utilising several designs to test competing hypotheses, creating the possibility of several competing management alternatives which can be tested to determine which produces the best results (Resilience Alliance, 2010). For a government to be resilient, officials should not be preoccupied with control as this undermines the flexibility of systems, rather government should focus on improving its adaptive capacity process (Garmestani and Benson, 2013). It should be noted that like all forms of governance, adaptive governance can only be adopted effectively if officials are honest and committed (Lewis, 2017)

Polycentric governance, as already previously noted, is another fundamental principle of resilience, can improve resilience of socio-ecological systems and the impact of corruption on service delivery (du Pisanie, 2004; Ostrom, 2010). Polycentric governance requires multiple nodes of power that operate in an integrated system of governance (Armitage, 2006; Ostrom,

2010). The separation of powers theoretically makes it more difficult to engage in corrupt activity (du Pisanie, 2004). Whilst polycentric governance can improve resilience, there has to be alignment within and between the different spheres of government, particularly when dealing with cross-cutting issues like climate change, as responsibility must be delineated to effectively deal with these issues (Mulgan, 2002; Garmestani and Benson, 2013). In contrast to rigid monocentric governance structures, polycentric governance can enhance resilience in six ways: it provides opportunities for learning, improves connectivity, self-sufficiency, response diversity, builds redundancy and enables broader participation (Biggs *et al.*, 2015).

The capacity of an organisation (in the case of this study local government) to learn has also been described as an important component of improving resilience (Pahl-Wostl, 2009; Harrison *et al*., 2014). To enhance learning capacity, it is necessary for government to develop and promote a culture of learning and experimentation by building learning infrastructure and rewarding innovation (Pahl-Wostl, 2009; Harrison *et al*., 2014). It would also be necessary for government to facilitate the sharing of information and knowledge. The constraints to such an approach, in the context of government and some organisations, is the bureaucratic mind-set, which usually rewards conformity rather than innovation. Employees are hesitant to experiment because mistakes are punished (Pahl-Wostl, 2009; Harrison *et al*., 2014). The safe-to-fail concept has been suggested as a solution to enhance innovation as it allows for learning opportunities even if mistakes are made, by utilising feedback loops. However, the safe-to-fail concept should be used only in certain scenarios, as in some cases a failure can lead to disastrous consequences. If the concept is applied it should be done in an incremental manner such that failures can easily be rolled back (Pahl-Wostl, 2009; Harrison *et al*., 2014).

The resilience thinking approach discussed above investigates how interacting systems of nature and people, can be managed in the face of uncertainty and disturbance (Biggs *et al*., 2015). This entire approach utilises systems thinking to determine how to manage this system (Harrison *et al*., 2014). Systems thinking is a holistic approach to analyse the way a system's constituent parts interact. Resilience thinking requires that a systems approach is considered throughout the implementation of the principles of resilience (Ballew *et al.*, 2019). Systems thinking in the case of climate resilience thinking requires that every process be assessed on the impact it will have on the environment, the economy and society (Biggs *et*

al., 2015). Studies indicate that systems thinking reduces wasted time, resources, and ensures that society has an improved understanding of their effect on the environment (Ballew *et al.*, 2019).

Systems thinking is a holistic approach to analyse the manner in which a system's constituent parts interrelate and interreact, and how that system works overtime. An example of systems thinking is Cape Town's response to its water crisis (Enqvist and Ziervogel, 2019), which was managed drawing on systems thinking (Matikinca *et al.*, 2020). During 2017-18, the City of Cape Town suffered a drought so severe that its residents faced the prospect of a 'Day Zero', which would have been the day the taps ran dry (Rodina, 2019; Muller, 2017). The desperate situation forced Cape Town into embracing elements of a systems thinking in order to avert water shortages. The City embarked on a number of actions including enforced water restrictions, tiered pricing, enforcement of by-laws and has developed alternative sources of water supply, including ground water and desalination (Rodina, 2019). The City always had a robust understanding of its surface water supply and has enhanced this function further (Muller 2017, Rodina, 2019). The cumulative effect of these changes has made the City of Cape Town more resilient to droughts, however the City is cognisant that more needs to be done as it will face increasingly drier conditions as a result of climate change (Rodina, 2019).

2.3 Implementing climate change resilience planning into government policy

Thus far, the literature review has focused on the origins of resilience planning and the principles that underpin resilience thinking. The purpose of this study here, however, is to determine the level of *climate change resilience planning in government*, in this case the City of Johannesburg (CoJ). Building climate change resilience in a country, province or city, would in the main, adopt many of the same broad aspects of resilience discussed above (Harrison *et al*., 2014). There is some divergence, however, between resilience and climate change resilience, as climate change resilience embeds the environment, particularly climate change adaptation and mitigation, into as many guiding principles as possible (Folke, 2006; Nelson and French, 2002). To understand how resilience, particularly climate change resilience, can be implemented as a planning tool instead of only being seen as an abstract concept, some of the various frameworks and strategies in planning literature, which can be

used by government institutions to become more resilient, are examined below (De Roo and Juatsiniemi ,2010; Davoudi et al., 2012; Taşan –Kok *et al*., 2013).

Jabareen (2013), for example, has created a conceptual framework for resilient cities, although there are several others (Desouza and Flanery, 2013; Hernantes *et al*., 2019) which is comprised of four interrelated concepts (Jabareen, 2013). Concept one calls for a city to develop a vulnerability analysis matrix, which will map future vulnerabilities and risks. This matrix is envisioned to identify and analyse types, intensity, spatial distribution, and scope of risks which affect cities (Jabareen, 2013) and seeks to address how these risks affect the urban population (Committee on Climate Change, 2010). Vulnerability in the context of climate change refers to "the degree to which a system (geophysical, biological and socioeconomic) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2007; Scott *et al*., 2019). Jabareen's (2013) vulnerability analysis matrix assesses the demographic and social-economic aspects of urban vulnerability (Ojerio *et al.*, 2011), the scale and conditions of informal urban spaces (Roy, 2010), environmental uncertainty (Abbott, 2009) and spatial distribution of vulnerabilities (Satterthwaite, 2008). These four components of the vulnerability analysis matrix determine the scope of a risk and its environmental, social and spatial effects (Jabareen, 2013).

In addition to the afore mentioned conceptual framing the governance dimension, as has been shown, is also essential. For a city to be resilient it needs to be inclusive in its decision making and be flexible in the way it responds to change (UNISDR, 2010; Jabareen, 2013). To make urban areas resilient, two components need to be entrenched in urban governance; these are an integrative approach to enhance urban governance and equity (Jabareen, 2013). An integrative approach requires the expansion and improvement of capacity within a city to cope with climate change risks and vulnerabilities (Mirfenderesk and Corkill, 2009). It requires the integration of as many stakeholders as possible in planning processes to get buy-in for process change, thus achieving change (Romero-Lankao, 2007). Equity encompasses social justice issues and is central to shaping resilience (UNISDR, 2010). The effects of Hurricane Katrina on the United States of America, for example, showed that, for a city to be

resilient for all its citizens, it needs to have fewer social inequalities and resources need to be fairly distributed (Satterthwaite, 2008; Kaika, 2017).

Prevention and effective risk reduction are additional conceptual design elements which suggests that, for urban centres to become more resilient, they need to work towards lowering the risks of environmental hazards (Jabareen, 2013). This concept has two components which aim to prevent future calamities: mitigation, restructuring and alternative energy. These two elements are crucial to reducing hazards and creating a spatial structure of the city that is prepared for any future environmental disaster (Jabareen, 2013). Mitigation demands the implementation of policies and actions that reduce or limit GHG (greenhouse gas) emissions (Committee on Climate Change, 2010). The effect of reduced emissions at the local level, has several benefits including a reduction in respiratory diseases and enhances pollination (Jabareen, 2013). Restructuring represents the ability and flexibility of a city to restructure environmental risk responses based on environmental, social and economic challenges. An example would be shifting the economy because of drought from one based on agriculture to a services-based economy (Cooke and Piccaluga, 2006).

Mitigation and climate resilience as understood by several studies is the decoupling of economic growth from resource use (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood *et al.,* 2019). This principle embraces the concept of reducing the negative effects on the environment in absolute terms. This means CO2 emissions are considered per annum rather than reducing negative emissions per unit of output, which talks to optimisation (Haywood *et al.* 2019). Ensuring the decoupling of economic growth from resource use, should reduce greenhouse gas emissions, thus contributing to the mitigation of climate change.

Uncertainty-oriented planning is an additional conceptual design element, which requires that planning should be proactive rather than reactive (Jabareen, 2013). Climate change challenges the conventional approach to planning because of its uncertainties. The conventional approach to urban planning relies on trying to predict the most probably future and planning for that while uncertainty-orientated planning attempts to plan for a range of possible futures (Chakraborty, and McMillan, 2015). Jabareen (2013) identifies three interrelated components which can improve resilience planning for climate change in urban areas. These are *adaptation, effective spatial planning and a sustainable urban form* (Wardekker *et al.*, 2010; Zhang, 2010; Meijer *et al.*, 2011). Climate change adaptation, in the

urban context, refers to modifying social and ecological systems in urban areas to accommodate climate change such that these systems are enabled to persist over time. Adaptation policies can fall into two categories: *ex-ante* management, which is proactive approach or *ex-post* management which is reactive. Jabareen (2013) calls for both types of management as he believes they are both crucial for resilience (Wardekker *et al.,* 2010; Jabareen, 2013).

Effective spatial planning is considered crucial to improving the resilience of urban areas. Thus, urban planners should create plans to reduce vulnerability to hazards. Land use management is essential and effective building and site design codes need to be created to regulate development (Zhang, 2010). Sustainable urban forms have important synergies with effective spatial planning and will inform the way development occurs (Bay and Lehmann, 2017). Jabareen (2013) has identified several elements which can improve a city's resilience. Sustainable transport is regarded to be a critical component to ensuring a sustainable urban form and would include large scale public transport, non-motorised travel and transit-oriented development, which is development situated around transit nodes (Elkin *et al.*, 1991; Wheeler, 2002). High density development is crucial to sustainable development as it reduces emissions significantly, however it has implications on adaptation by increasing the urban heat island effect and decreasing infiltration of water (Jabareen, 2013).

Sustainable urban form demands that planners locate compatible land uses near each other to reduce travel distances. Thus, planners should create mixed land use zones which comprise of residential, industrial and commercial zones. This will reduce the need for travel as jobs, leisure activities and shops will be near housing (Wheeler, 2002). Green infrastructure is essential to a sustainable urban form, which includes everything from storm water infrastructure to renewable energy like solar and wind farms (MacKillop, 2012). There are numerous studies which have determined that urban areas have the potential for passive solar designs which reduce energy demands by utilising passive energy through design and planning measures (Abbate, 2008).

Sustainable urban form also requires the greening of an urban space by bringing nature into it through parks and nature reserves, which studies have shown provide essential ecosystem services while also improving social and economic cohesion (Forman, 2002; MacKillop, 2012). The renewal and utilisation of urban areas that are no longer used for their intended

purposes (brownfields) and can be utilised for different purposes are key to revitalising cities while contributing to sustainable development and a healthier urban environment (Jabareen, 2013).

2.4 Climate change and resilience thinking in South African government policy

Having outlined and described some of the nuances of the various understandings of concepts in the wider climate change and development context, attention now turns to examine how these terms are being taken up and mainstreamed in wider government policy.

A brief overview of South African government policy shows that government has a good understanding of climate change, with numerous policies and frameworks developed across all spheres of government (Perine and Keuck, 2018). Mitigation has been the foremost strategic focus of funding and policy. Adaptation, has however, increasingly also become a priority across all spheres of government, with the establishment of a designated unit at the Department of Environmental Affairs (Directorate - Climate Change Adaptation), as well as the National Adaptation Plan (DEA, 2020). Notwithstanding these developments, climate change policy in South Africa to date still tends to be done largely in isolation, with mitigation and adaptation treated in silos (National Planning Commission, 2012; Perine and Keuck, 2018). At the local government level, big metros including Johannesburg, Durban and Cape Town, are holistically managing climate change, with programs like Climate Action Plans (CAPs) under way (Roberts and O'Donoghue, 2013; Vogel *et al*., 2021).

CAPs address mitigation and adaptation holistically as required by climate change resilience (C40, 2021). The CAPs are developed based on the Climate Action Planning Framework developed by C40 Cities Climate Leadership Group, to deliver the goals of the Paris Agreement (C40, 2021). The CAPs have two key objectives, the first is delivering a pathway to an emissions neutral city by 2050 and the second is improving the resilience of a city to climate hazards that may impact the city now and in the future (C40, 2021). The CAPs are developed with inclusivity and collaboration as key principles underpinning the process (C40, 2021).

Resilience thinking has also permeated into many policy documents, for example, the South African government is polycentric with multiple nodes of power (Schmidt, 2008). It should be noted that polycentric governance in South Africa was developed for several reasons

among them resilience (Scholte, 2004; Muller, 2012). Each node of government has legislative and executive authority within their spheres of influence (Constitution and Devenish, 1996). The way the constitution of the country defines the government's arrangement aligns it with several aspects of resilience thinking. South Africa's three-tier system of government and an independent judiciary are defined as being interdependent, interrelated and distinct which is an aspect of resilience planning (Constitution and Devenish, 1996). Furthermore, governance in South Africa is intended by the constitution to be participatory and co-operative, which are also key aspects of resilience thinking (Schmidt, 2008).

2.5 The importance of cities in addressing climate change

Having outlined the importance of climate change in South Africa's national and local policy landscape and the inclusion of the fundamental principles of resilience in this policy landscape, attention turns towards cities and their role in addressing climate change.

Since the 1980s climate action by cities has been regarded as crucial towards addressing climate change, as cities are home to over half of the global population and are responsible for over 70% of greenhouse gas emissions (Brundtland Commission, 1987; Hoornweg *et al*., 2011). Traditionally, cities have been located near oceans or rivers for connectivity and transportation purposes (Hoornweg *et al*., 2011). What was once a geographical advantage has now become a vulnerability as sea levels rise and rivers flood. Fifteen of the world's twenty megacities are at risk because of sea level rise and coastal flooding which has made flood protection works and other adaptive measures necessary (McGranahan *et al*., 2007; Hoornweg *et al*., 2011). Inland cities also face climate change risks which will require adaptations such as improvements to storm water infrastructure to better deal with high intensity rainfall, which can lead to flooding if not properly addressed (Hoornweg *et al*., 2011; Bulkeley, 2013).

Although the concentration of people, motor vehicles and industry in cities is seen as a problem, the high densities of people also provides advantages for meeting human needs and for climate change mitigation (Dodman, 2009). Urban density, for example, influences the amount of energy used for private transport, with studies showing that the most densely populated cities utilise less energy for transport per capita than residents elsewhere in the

same country (Newman, 2006; Dodman, 2009). Cities can play a significant role in addressing climate change, as cities are responsible for energy and transportation management, building requirements, land-use planning and waste management (Dodman, 2009). These responsibilities allow cities to be more agile in the way they respond to change and are thus useful in addressing climate change (Hunt and Watkiss, 2011). The significance of this ability is evident in the way strategies to address climate change are being redrawn globally at national government level to include a significant role for cities (Jabereen, 2013).

The concentration of industries and people in cities provides the opportunity for innovation and the rapid spread and adoption of solutions, both behavioural and technological (Bulkeley and Betsill, 2013). In Nairobi, the use of low technology Improved Cookstoves (ICS) was accelerated by the promotion of the product through a television program called the 'Great African Cook-off', these stoves provide substantial environmental as well as health benefits in comparison to using solid fuels for cooking (Jeuland and Pattanayak, 2012; Hartley et al. 2019). Well planned and managed cities can play a central role in climate change mitigation, through improving infrastructure and strengthening by-laws (Dodman, 2009; Bulkeley and Betsill, 2013). In Vienna, for example, energy efficiency spread rapidly throughout the city, because it was trendy and was incentivised by the City (Dodman, 2009).

In the South African context, as discussed previously, several policies are now also being framed at the City level that have been clearly influenced by resilient thinking and planning (C40, 2021; Vogel *et al*., 2021). Cities trying to include a focus on both resilience and planning are those of the City of Cape Town and Durban (C40, 2021). As mentioned previously, the City of Cape Town's response to the water crisis it faced potentially enhanced that City's resilience to future water scarcity scenarios (Rodina, 2019). The City of Cape Town has made explicit references to building resilience in the water sector as a priority (Rodina, 2019). The City of Durban has prioritized climate change adaptation and local level resilience since 2004, when work began on developing and implementing a Municipal Climate Protection Program. This program was strongly focused on adaptation or resilience-focused interventions, for example, capacity building in the City's Disaster Management Unit which would be needed to deal with potential climate disasters (Roberts, 2010).

2.6 Johannesburg and climate change

Having outlined the importance of climate change to cities and the emergence of a climate resilience planning landscape in South Africa in the previous two sections, attention now turns to the focus of this research, the City of Johannesburg (CoJ). The CoJ is the financial and economic hub of South Africa, with the City accounting for 16% of South Africa's GDP (Beall *et al.*, 2014) and is the most populous city in South Africa, with a population of approximately five million people (Statistics South Africa, 2015; CoJ, 2018). The CoJ occupies a land area of 1645 square kilometres, which is large compared to other major cities globally (Statistics South Africa, 2015). It is a metropolitan municipality which, unlike district and local municipalities, can execute all the functions of local government. This allows for effective integrated development planning (IDPLG, 2018). The CoJ is organised into seven regions, named alphabetically (Figure 1). The CoJ was divided into regions in 2006, this process was intended to improve service delivery within the City, by separating powers between the legislature and the executive in the City (Rogerson and Rogerson, 2016).

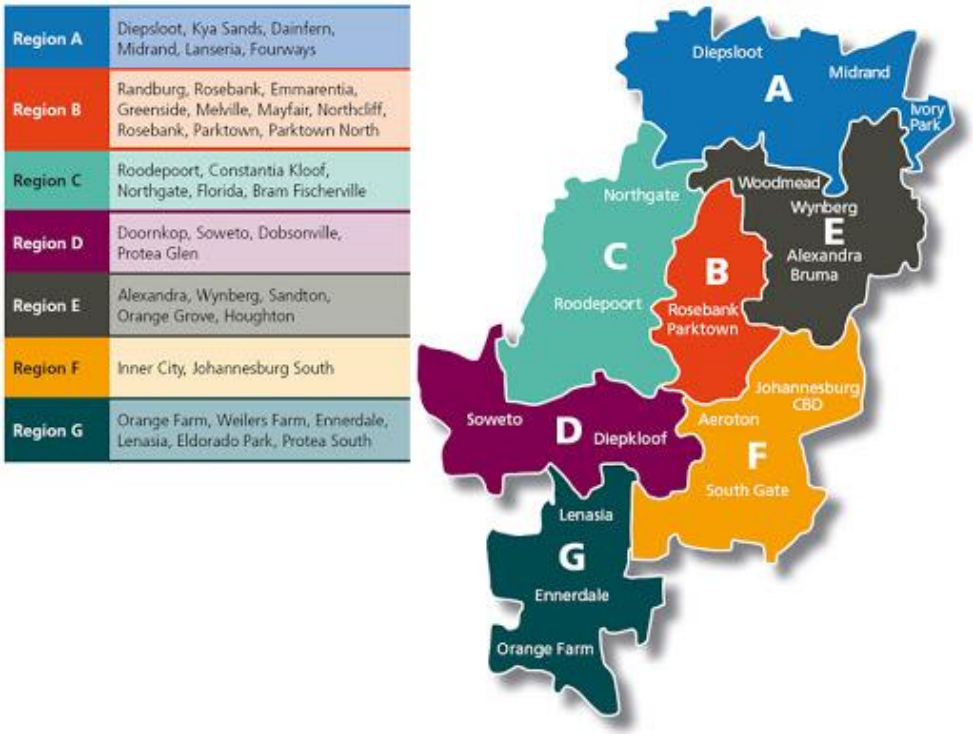

Figure 1. Map of CoJ, broken into its regions (Pikitupco, 2019)

The CoJ's structure mirrors that of national and provincial government and is made up of a legislative arm (the council) and an executive arm (comprised of the executive mayor and the

mayoral committee) and finally an administrative arm (CoJ, 2016a). The council is focused on legislative, participatory and oversight roles and delegates its executive function to the mayor and mayoral committee (CoJ, 2016a). The administrative arm is responsible for the actual operations of the city together with the City's municipal owned entities. The CoJ has nine municipal departments and is unique amongst South African municipalities in that it has several Municipal Owned Entities (MOEs) that are responsible for the implementation of projects, the CoJ owns thirteen such entities (Figure 2). The CoJ introduced these entities, to increase accountability as they were corporatized (Cartwright and Marrengane, 2016).

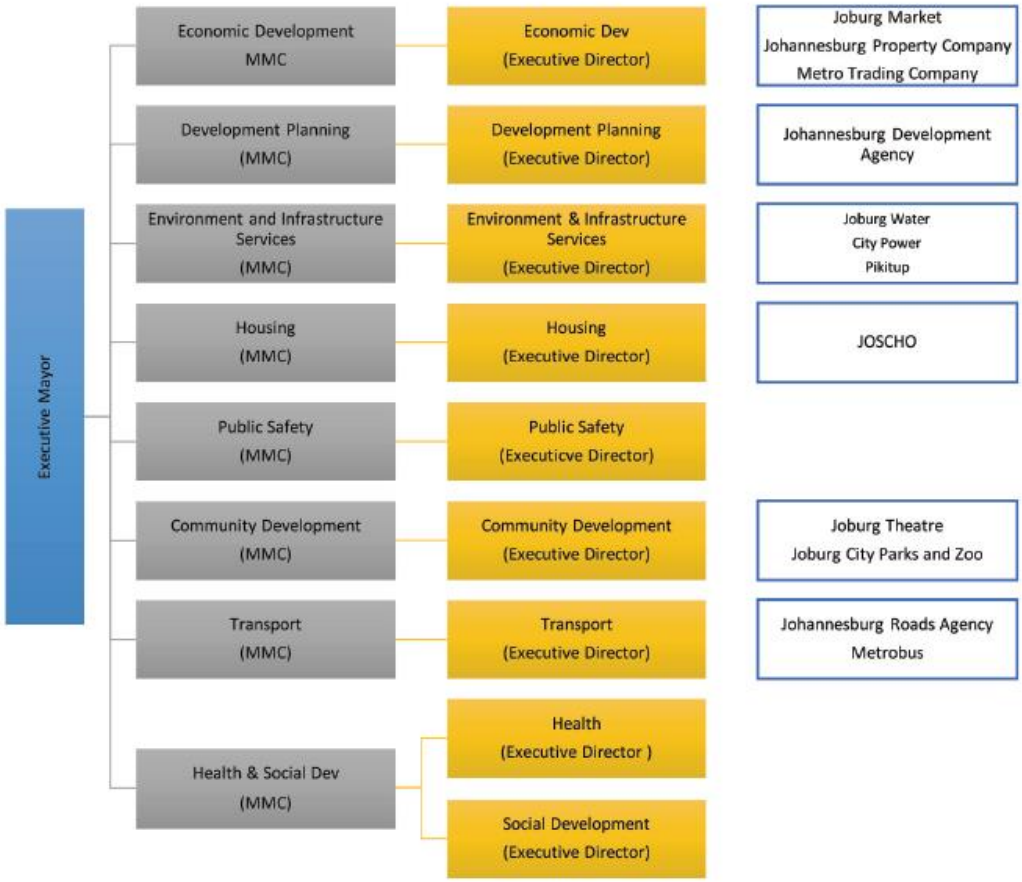

Figure 2. Organisational structure of the City of Johannesburg (CoJ, 2016a)

Like other South African cities, the CoJ faces significant social-economic challenges like high unemployment and low income, high crime rates, corruption and significant service delivery issues (Rogerson, 2018). South Africa's urban areas are still affected by apartheid

era spatial planning, which established townships (for Indians, Africans and Coloureds) on the periphery of urban areas often close to industrial areas but disconnected from commercial districts (Rogerson, 2018). This spatial planning has had serious implications for the sustainable provision of public utilities, transport, and economic infrastructure, as well as significant climate change implications (Todes *et al*., 2010).

The CoJ is a city that by international standards, has limited exposure to the effects of climate change, since it is not a coastal city nor is it located in an area heavily affected by natural disasters (Theeboom *et al*., 2009; CoJ, 2015). However, the projected climate change impacts for the CoJ are still substantial and significant. The CoJ's primary identified climate change risks are water scarcity, urban flooding and heat waves (Theeboom *et al*., 2009; CoJ. 2015). These three factors have serious implications on food production, water resources, human health and infrastructure. For example, urban flooding impacts the quality of ground and surface water, increases the risk of infectious disease outbreaks and damages and destroys infrastructure (CoJ, 2015; Global Change Institute, 2018).

The CoJ is not only impacted by climate change but is a contributor to climate change because of its GHG emissions (EcoMetrix Africa 2015). The CoJ is one of the largest GHG emitters in South Africa and in the world. Because of its role in climate change and the challenges it faces because of climate change, the CoJ has set targets to reduce emissions and has plans to improve the adaptive capacity of the CoJ (EcoMetrix Africa 2015). The CoJ recently approved its Climate Action Plan (CAP) which was developed with the assistance of C40. The CAP is intended to be ambitious and actionable (C40, 2021).

The concept of resilience gained prominence in the CoJ's planning discourse, during the GDS process (Peyroux, 2015). The GDS was developed with substantial support from international and local experts, and the regular interaction between City officials and experts from the South African Cities Network (SACN) contributed to the adoption of resilience into the strategy (Peyroux, 2015). Resilience in the GDS is derived from the evolutionary and systems perspective of resilience (Peyroux, 2015). "*Resilience is the capacity of a system to continually change and adapt, yet remain within critical thresholds – even when confronted with the unexpected. Building resilience is critical, as without it, valuable economic, cultural, knowledge, institutional and ecological networks and systems may be lost or damaged – necessitating different configurations*' (CoJ, 2011: p. 23-24). It should be noted that the CoJ's

definition of resilience differs from the definition of resilience as understood by this study "*City resilience describes the capacity of cities to function so that people living and working in cities – especially the poor and vulnerable – survive and thrive no matter what shocks and stresses they encounter*" (Rockefeller Foundation and ARUP, 2014: p. 3). The difference in definitions should not have an impact on this study, as this study evaluated policies using a scorecard that evaluated whether the principles of resilience were incorporated in a policy rather than the definition of resilience used by a policy (Chapter 3.1).

The SACN has classified the CoJ as a City as an emerging resilience system (SACN, 2014; Kareem *et al*., 2020). Cities were ranked by SACN based on the following criteria: (1) Analysing the link between service delivery and climate change, to understand whether the City has made the link; (2) Identification and evaluation of existing climate change and resilience initiatives; (3) identification and evaluation of the climate change related risks on water, energy and food security and whether there are any potential adaptation measures; and (4) a climate change resilience assessment (SACN, 2014). The CoJ based on these criteria was classified as a city with an emerging resilience system (SACN, 2014)

The CoJ has been observed to be more proactive than its local peers in its attempts to become climate resilient and has made reference of resilience and climate change in its long-term planning documents, like the *Growth and Development Strategy* (GDS) *2040* and the CoJ's various *Integrated Development Plans* (IDP) (SACN, 2014; Peyroux, 2015). The CoJ has developed several climate change policies including climate adaptation plans (vital for enhancing resilience) and has developed greenhouse gas inventories. Up until recently, however, the CoJ has not been implementing and integrating its climate change policies and plans for a number of reasons, including political barriers, the lack of cross-linkages between development and climate change and a tendency towards short-termism (Hetz, 2016; Vogel *et al.,* 2021).

Having outlined the context of resilience and climate change in South Africa in general and the CoJ specifically, focus now shifts to the political landscape. Which as discussed previously, is critical as governance and government actions also influence the framing of how actions on climate resilience are undertaken.

2.7 Political landscape of the City of Johannesburg

South Africa has two election cycles, both of which take place every five years. National and provincial elections are held simultaneously, and municipal elections take place two years later (Paret, 2018). The CoJ as a municipality follows the second cycle of elections, i.e., the municipal election cycle. Municipal elections in Johannesburg saw a record number of political parties contesting the elections (forty-three) (Nyenhuis and Krönke, 2019).

The 2016 local government election, as noted above, was historic in that Johannesburg for the first time since democracy, had a handover in power from the African National Congress (ANC) to a Democratic Alliance (DA) led coalition (Nyenhuis and Krönke, 2019). It should be noted that the ANC had the highest number of votes in the City, however they could not form a majority government. The DA then formed a coalition government together with several other political parties thus taking control of the City (Nyenhuis and Krönke, 2019). It should be noted that the City of Johannesburg is now governed by the ANC after the DA's coalition collapsed in 2019, shortly after its mayoral candidate resigned (Harper, 2019).

Change in government globally has been understood to result in significant upheaval in government departments, with the new government department replacing executive heads and changing policies (Clar and Steurer, 2019). Change in government could either be positive for climate change or negative depending on the importance of climate change to the new government, for example in the United States the change in government from the Democrats to the Republicans was detrimental to climate change, as Donald Trump and his colleagues did not believe in climate change (Goldstein and Greenberg, 2018). The ANC in the City of Johannesburg made a strong political commitment to climate change, with the recent approval of its Climate Action Plan, wherein the City committed to transitioning the CoJ into a carbon neutral and resilient City by 2050. The CoJ within the CAP has identified several focus areas, where implementation must be made to achieve the goals of the CAP. The CoJ must also ensure that this plan is actionable (CoJ, 2021).

Having outlined the context of the CoJ, the role of some of the politics in the City and the uptake of some of the climate change discourse in the City attention now turns to further understand how this discourse is being understood by focusing on one sector in detail namely water.

2.8 Water and climate change

One sector, when examined more closely, clearly illustrates the intersectionality and links that climate change has to all local government planning divisions. Water is the lifeblood of our planet, and the state of this resource affects all economic, social and natural systems (Muller, 2007). Water is regarded as a fundamental link between the climate system, environment and human society (OECD, 2013). Climate change is impacting the hydrological cycle, by increasing evaporation and precipitation, but the additional precipitation will be unequally distributed, and which will have a significant impact on human development (OECD, 2013; UN-Water, 2018).

Water scarcity affects more than 40% of the global population and this figure is expected to increase because of climate change (IPCC, 2008; OECD, 2013). In 2011, 41 countries experienced water stress, ten of these countries are close to depleting their supply of renewable freshwater and will need to find alternative sources. It is expected that because of drought and desertification this number will only grow (OECD, 2013; UN-Water, 2018). It is predicted that sub-Saharan Africa will be one of the regions most affected by the impacts of climate change on its water resources (Vörösmarty *et al*., 2010; OECD, 2013).

Climate change not only reduces the availability of water, but also increases water related risks like floods, droughts and storm surges (OECD, 2013). These events will put additional strain on water resources management, as it increases uncertainty about quality and quantity of available water. These risks are expected to continue regardless of any mitigation measures that may take place, thus society will need to adapt to these changes and develop water infrastructure and services that are more resilient to these changes (Vörösmarty *et al*., 2010; OECD, 2013). In urban areas, water and wastewater systems should provide clean water for different users, remove wastewater to prevent unsanitary conditions and redirect storm water flows to avoid waterlogging and prevent flooding (Muller, 2017). Climate change is expected to affect service delivery by reducing the supply of water, increasing the cost of treating wastewater and causing flooding and waterlogging (Muller, 2017; OECD, 2013).

Municipalities will need to increase their supply of water by changing consumption patterns and making their water resources more resilient, by adding alternative water resources to their

supply (Brown *et al.,* 2009). The cost of treating wastewater is increased because the standards for wastewater treatment are dependent on the extent to which effluents should be diluted before they are discharged. Thus, if stream flow is reduced, treatment will need to be intensified to maintain the same standards, thus increasing costs. Climate change is expected to increase the intensity of rainfall and therefore flooding, this will increase the costs of storm water infrastructure and flood protection works (Brown *et al.*, 2009; OECD, 2013).

The City of Johannesburg, as mentioned previously, is unique in that the City of Johannesburg is one of the few major cities that is not located on a lake, seashore, or river (Turton *et al*., 2006). The CoJ, however, does straddle a major watershed, the Witwatersrand. This watershed is located at the headwaters of two major river basins, the Limpopo and Orange rivers (Turton *et al*., 2006).

The City of Johannesburg thus has two major responsibilities, the first is ensuring adequate water supply is available to its citizens and the second is ensuring that the Witwatersrand watershed is kept pristine, as pollution that occurs in it has impacts on downstream users as far away as Zimbabwe (Turton *et al*., 2006; Njinga and Tshivhase, 2017). There are several other dimensions to the issue of water, water security and scarcity and climate change adaptation that lie beyond the scope of this work.

Water management in the CoJ is cross functional within the City, with several departments and entities contributing, however the primary department and entity responsible for water management is the Environment Infrastructure and Services Department (EISD) and Johannesburg Water (JW) respectively. The City of Johannesburg established JW to ensure that adequate water supply is available to the citizens of the CoJ as mandated by the Water Services Act of 1997 (Johannesburg Water, 2020). The main function of JW is to deliver water and wastewater services in the CoJ (South African Local Government Association, 2011; Johannesburg Water, 2020). EISD is responsible for the development of policy and guidelines that deal with the protection of water resources and ensuring that implementation of these guidelines and policies occurs (CoJ, 2016a).

The CoJ water supply systems are insufficient for the needs of the citizens of the City. The poor levels of service delivery are attributed to aging infrastructure and the lack of capacity in the CoJ's functional areas that are responsible for water management in the City (Wolf, 2018). A study by Wolf, on the resilience of Johannesburg's water management landscape

found that current approaches to water management in the City are lacking, as they create compartmentalisation which affects service delivery (Wolf, 2018)

2.9 Conclusion

Climate resilience planning adds an exciting dimension to policy and planning (Davoudi *et al.*, 2012). While it is clear that resilience and climate resilience is understood differently by different authors and the malleability of the term can result in resilience becoming just another buzzword (Davoudi *et al.*, 2012), it is also clear that if used correctly, the holistic nature of resilience makes the concept promising for climate change planning and practice (Taşan –Kok *et al*., 2013). It is the opinion of this author and several others that it is not the term resilience or climate resilience that matters, but rather the effective inclusion and implementation of the principles of resilience and climate resilience within policy and practice (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016).

While there are numerous frameworks and tools kits for implementing climate change resilience within government (Desouza and Flanery, 2013; Jabareen, 2013; Hernantes *et al*., 2019), the fact that the City of Johannesburg has been identified as having an emerging climate resilience system (SACN, 2014) prompted this evaluation of the City in terms of resilience planning, utilising a framework that begins to evaluate, the extent to which resilience is being currently addressed. It was for this reason that this study, the framework developed by the Council for Scientific and Industrial Research (CSIR) and PricewaterhouseCoopers (PWC), 'Building Resilience into Business Strategy, Management and Reporting' (Haywood and Van der Watt, 2016), was trialed as the base for the scorecard used to evaluate the CoJ's policies and plans.

This framework was selected as it was developed specifically to examine the extent to which a business entity has begun to address resilience. This framework was modified to better fit the requirements of this study, by including additional components from current best practice literature in climate resilience planning as discussed in Section 2.2 (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016).

Chapter 3: Methodology

In this chapter the research methodology used in this study is presented. The City's strategic policies that were assessed in this study are presented. The chapter is laid out as follows, Section 3.1 introduces the policy analysis component of this study and will include the reason behind the selection of certain policies, and the way these policies were evaluated. Section 3.2 introduces the interview process and will include the selection criteria for individuals interviewed and the methodology used to develop the interview schedule. Section 3.3 discusses the data analysis component of this study.

It should be noted that this author was employed by the CoJ for several months, within the Environment, Infrastructure and Services Department (EISD). Employment within the City has enabled this author to have insights into policy that other individuals may not have and ensured access to certain officials and also to various documents, which although in the public domain, may be difficult to locate. Additionally, the personal relationship between this author and several officials interviewed may have influenced the information shared. These issues linked to my positionality were covered in my ethics application and were carefully considered throughout the engagement process as will be show below.

3.1 Policy Analysis

The aim of this study is to assess to what extent the CoJ embeds climate change resilience planning and relevant resilience implementation in its policies. The nature of the study dictated the approach. Contextual analysis is a research tool, used specifically to determine the presence of themes or concepts within qualitative data (Iversen and Gudmund, 1991). This data can be from field research notes, interviews, books or any other occurrence of communicative language (Iversen and Gudmund, 1991). To analyse data, the information is broken down into discrete categories for analysis. There are two broad categories of contextual analysis, conceptual and relationship analysis, conceptual analysis determines the presence and frequency of a concept in the data set, while relationship analysis determines the relationship of the data to the concept (Iversen and Gudmund, 1991). This study will utilise the latter category, as the study intends to determine the relationship the CoJ has with resilience planning as a concept.

The content analysis used relied on a scorecard to evaluate the policies against. The scorecard approach was selected as it is a useful method for evaluating qualitative data, such as the policies that this study seeks to assess. This method is limited by the indicators of the scorecard and therefore a scorecard should be used (Dias-Sardinha and Reijnders, 2005).

A scorecard was therefore created based on the current best practice literature in climate resilience planning against which the climate change planning in the CoJ could be evaluated. This scorecard incorporates the key principles of resilience as identified in the literature (see Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016), and included the CSIR's 'Building Resilience into Business Strategy, Management and Reporting' template (Haywood and Van der Watt, 2016) that is used to assess the resilience of businesses, together with the Stockholm Resilience Centre: Seven principles for resilient socio-ecological systems and Urban Resilience Thinking for Municipalities (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016). The derived scorecard comprised of fifteen criteria, each of which was tied to a score of zero (low) to three (high) (Appendix 1; Table 1). The maximum overall score that could be achieved was 45 per document. Table 2 below indicates the general manner in which scoring occurred, using criterion six as an example (see Appendix 1 for the detailed scorecard).

Table 1. Policy assessment scorecard (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016)

Criterion	Rationale
1. Does the document show accountability toward the socio-ecological system, in terms of systems thinking?	These two questions focus on systems thinking which are important components of resilience planning as indicated by chapter 2.2
2. Does the document recognize that government operates within a socio-ecological system that it shares with multiple users and does it recognize the impact that government has on this system?	
3. Does the document show that government recognises major social, ecological and economic risks that the City faces?	These two questions focus on risk and adaptation which are critical components of resilience planning as indicated by chapter 2.2.
4. Does the document suggest that government plans to mitigate risk, and does it address the adaptive capacity of the socio-ecological system?	
5. Does the document indicate that government consider its resource use and environmental impacts?	These two questions focus on the decoupling of economic growth which are critical components of climate resilience as it enhances mitigation efforts, as indicated by chapter 2.3
6. Does the document indicate that government makes investment in natural and social capital?	
7. Does the document indicate that government utilises adaptive governance as envisioned by resilience planning?	These two questions focus on the governance principle which are critical components of resilience as indicated by chapter 2.2
8. Does the document indicate who are key stakeholders for government and who is responsible for decision making in government?	

9. Does the document indicate that government considers income disparities or inequalities in its planning?	Equality is critical to climate resilience as climate shocks will affect different communities differently, as indicated by chapter 2.3
10. Does the document indicate what is the planning horizon for strategy and operations?	These three questions address the innovation and foresight principle of resilience, which as indicated by chapter 2.2 is important in ensuring the resilience of a government
11. Does the document indicate that government promotes learning and to what extent?	
12. Does the document indicate that government is innovative?	
13. Does the document indicate that government manages its slow variables and feedback loops?	Slow variables and feedback loops are important to resilience as the management thereof ensures the long-term resilience of government or society and indicated by chapter 2.2
14. Does the document make provision for diversity and redundancy in the way it deals with various challenges that affects government?	The redundancy and connected principle is important to the resilience of government, as it ensures that a city is capable of dealing with shocks, including climatic as indicated by chapter 2.2.
15. Does the document indicate that government is both self-sufficient and connected?	

Table 2. Method of evaluation of the scorecard, (Criterion 6, Appendix 1)

Score	Requirement	Description
0	Non-compliance	No mention of the criterion, for example, no mention of whether investments are made in natural and social capital
1	Limited compliance	The criterion is acknowledged and there are plans to manage the criterion however there is no context for the plan, or it is limited. For example, mention is made that investments are made in natural and social

		capital however no indication on the reasoning behind this investment
2	Partial compliance	The criterion is acknowledged and there are plans to manage the criterion with context, however plans are developed in isolation and the criterion is not considered across the entire document. For example, mention is made that investments are made in natural and social capital and include environmental and social reasons for an investment rather than a holistic reason.
3	Complete compliance	The criterion is acknowledged and where possible the criterion is considered across the entire document. For example, mention is made that investments are made in natural and social capital and include holistic reasons for the investment.

The CoJ has numerous policies, strategies, and plans. The CoJ strategic policies include a long-term strategy, which is known as the *Growth and Development Strategy 2040*. The *GDS 2040* is an aspirational document that defines clear outcomes against which to measure progress. The CoJ also has an *Integrated Development Plan* (IDP), which serves as the medium-term strategy for the City, that is closely coupled to the *GDS 2040*. IDPs are mandated by the Constitution in terms of Section 152 and 153 (Abrahams, 2018). The Local Government Transitional Act (LGTA), 1993 which was amended in 1995 compelled local governments to engage in developmental planning. The main planning mechanism at the municipal level in South Africa is the Integrated Development Plan (IDP), which South African municipalities are legally obligated to develop.

The current *IDP* of the CoJ is for the period 2016-21, together with the *GDS 2040*, shapes policy and planning within the CoJ. These two documents are regarded as the key strategic documents of the CoJ and were therefore assessed in detail in this study. Additionally, the *IDP 17/18 Review* was further interrogated to understand how the change of ruling party may have affected policy and planning at the strategic level in the CoJ. The *IDP* for the period

2011-2016 was also evaluated using the framework unpacked in Appendix 1. It should be noted that with regards to *IDPs* evaluated, the *IDP 2016-21* was drafted by an ANC led council, while the *IDP 17/18 Review* was drafted by a DA led council. The political landscape of the City was discussed in the Chapter 2.8

An investigation into policy documents related to the water sector in the CoJ was also completed by searching the CoJ and its entities' websites. Insufficient policy documents were available on the website and so departments were contacted and requests for information were made. The following documents were shared by City officials:

1. *Integrated Environmental Management Policy*
2. *Catchment Management Policy for the City of Johannesburg*
3. *Sanitation Policy for the City of Johannesburg*
4. *Water Conservation and Water Demand Management: Framework Strategy*
5. *Disaster Management Strategic Action Plan*
6. *Johannesburg Road Agency (JRA) Strategy 2017*

The study of policy documents in the water sector, was limited to policy documents from departments or municipal owned entities that are responsible for the management of water within the CoJ, as discussed in the *IDP* 2016-2021 (CoJ, 2016a).

As mentioned previously, the policy analysis was completed using a scorecard derived from the CSIR's 'Building Resilience into Business Strategy, Management and Reporting' template (Haywood and Van der Watt, 2016). It should be noted that this framework, did not utilise any narrow evaluative criteria or other quantitative measures for example keyword analysis (Turok, 1991). Whilst attempts to be objective, in many instances analyse of policies was driven by judgement and interpretation, based on the understanding that policy objectives are seldom clear or detailed enough to permit the use of quantitative measures like keywords (Turok, 1991).

3.2 Interview methods

The desktop component of this study was then also complemented by a series of interviews with officials from the City of Johannesburg to determine whether resilience thinking is applied at a broad level across the CoJ.

A semi-structured interview approach was utilised, as it provides a balance between the focus of a structured interview and the flexibility of an open-ended interview. Semi-structured interviews also provide focused qualitative data (Cohen and Crabtree, 2006). Officials interviewed were selected through purposive sampling (Ames *et al.,* 2019) and were salso informed by my relationships with CoJ officials. As indicated before, I was employed as an intern in the CoJ in the EISD. This allowed me to gain a good understanding of key actors in the CoJ, in particular in the water sector. Any limitations of such knowledge and how it may have influenced the findings are discussed in the concluding sections of this work.

The interview schedule was derived from current best practice literature on climate resilience planning as previously outlined. It was guided by the key principles of resilience as identified in the literature (Harrison *et al.,* 2014; Biggs *et al.,* 2015; Haywood and Van der Watt, 2016), and the CSIR's 'Building Resilience into Business Strategy, Management and Reporting' template (Haywood and Van der Watt, 2016), the Stockholm Resilience Centre's: Seven principles for resilient socio-ecological systems and Urban Resilience Thinking for Municipalities (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016) (see Appendix 2 for interview schedule).

The intention was to conduct verbal interviews with government officials in English and all interviews were conducted in conducted in the City's offices. The interviews were conducted with officials who are subject matter experts within their departments from some of the following organisations, departments or entities:

1. Environment and Infrastructure Services Department (EISD), is responsible for policy and strategy of the environmental portfolio in the CoJ. EISD manages and implements measures to moderate pollutants in the City (CoJ, 2015). The department includes directorates such as water, waste, climate change amongst others. For the purpose of this study, it was essential to get a key respondent from the water and climate change directorates, as these directorates are responsible for climate change and water policies and strategies within the City (CoJ, 2015).
2. Johannesburg Roads Agency (JRA) is responsible for the management of roads and storm water infrastructure within the City of Johannesburg (JRA, 2017). Thus a key respondent from the JRA would be an individual that specialises in storm water infrastructure to understand whether the JRA considers climate change and is planning for resilience

3. Johannesburg Water is mandated to provide sanitation and water services to citizens of Johannesburg. Johannesburg Water is an entity that is wholly owned by the City of Johannesburg, is the primary provider of water and sanitation services to Johannesburg (JW, 2010) and was thus identified as a key respondent.
4. The Department of Public Safety is responsible for policy and strategy of the public safety portfolio in the CoJ. Public Safety manages and implements measures focused on moderating safety risks impacting the city. Its directorates include Disaster Management, Johannesburg Metropolitan Police and Emergency Management Services amongst others. Disaster Management provides direction for the implementation of disaster risk management policies and coordinates disaster risk management activities in the City (CoJ, 2020), hence a key respondent from this directorate was essential.
5. Strategic Coordination and Management Support provides the overarching strategic and policy frameworks to promote cooperative governance and facilitate developmental local government in Johannesburg (CoJ, 2020). Thus, a key respondent from this department was regarded to be crucial, as this department is responsible for the strategic direction of the CoJ.
6. Citizen Relationship and Urban Management (CRUM) is responsible for policy and strategy of the citizen management portfolio in the CoJ. CRUM manages and implements measures focused on improving service delivery in the City of Johannesburg and ensures that active citizenry occurs within the City (CoJ, 2020). A key respondent from this department would be valuable as it is a citizen-facing department, and they are aware of all service delivery related issues in the City).
7. The Department of Development Planning is responsible for policy and strategy of the development planning portfolio in the CoJ. The department manages and implements measures to reduce urban sprawl, improves bylaw enforcement and is attempting to create a well-defined north-south and east-west development axis, amongst other responsibilities (CoJ, 2020). The department has several directorates which are responsible for its various mandates, of which the land use management directorate would be a key respondent in the case of this study. The impact of a sustainable urban form is crucial for the resilience of a city, ensuring that this department was a key respondent.
8. The C40 Cities Climate Leadership Group (C40) is a group of 96 cities around the world that are focused on tackling climate change and driving urban action that reduces

greenhouse gas emissions and climate risks. Working across multiple sectors and initiative areas, C40 provides a suite of services including direct technical assistance and the facilitation of peer-to-peer exchange and research. C40 has a Climate Action Planning program that is operational in the City of Johannesburg, this has developed Climate Action Plan for the city that is implementable (C40, 2021). Due to the development of this document, the C40 officer in the city has a comprehensive understanding of the City's policy landscape and thus the City's C40 officer was interviewed.

Unfortunately, several of the intended interviews, despite several attempts to do so, did not take place for the following reasons: no response from a department/MoE or the individual contacted declined the interview request and would not identify an alternative. The COVID-19 pandemic also frustrated attempts to conduct interviews, particularly any face-to-face interviews. Interviews were therefore conducted with a single respondent from the following departments, organisations and MoE's:

1. EISD, Directorate of Climate Change, Energy and Air Quality on the 22nd of October 2019 at 10:00
2. EISD, Directorate of Water on the 21st of January 2020 at 14:00
3. Johannesburg Roads Agency on the 25th of October 2019 at 10:00
4. C40 on the 29th of November 2019 at 10:00
5. CRUM on the 29th of January 2020 at 11:00

It should be noted that only one of the interviews that took place was recorded, as per the request of the individuals interviewed.

All interviews conducted for this study took place in an ethical manner as stipulated by the University of the Witwatersrand's Ethics Codes and Procedures (see Appendix 3 for Ethics Approval Certificate). The interview schedule was shared with respondents prior to an interview, to ensure transparency. All respondents were made aware of the purpose and objectives of this research, through various means, including a Participant Information Sheet (PIS) and through a consent form, both of which were shared prior to an interview to ensure transparency.

3.3 Data analysis

All data generated by this study were qualitative, that is the data from both the policy analysis component and from the interview process. The small sample size of data associated with the policy analysis component of this study limited statistical analysis to descriptive statistics in the form of graphs, specifically spider diagrams.

The fifteen questions or criteria that formed the scorecard (Appendix 1) were broken down into its constituent principles of resilience as follows:

1. Criteria one and two: *Systems Thinking Principle*,
2. Criteria three and four: *Risk and Adaptation Principle*,
3. Criteria five and six: *Decoupling Principle*,
4. Criteria seven and eight: *Governance Principle*,
5. Criterion nine: *Equality Principle*,
6. Criteria ten, eleven and twelve: *Innovation and Foresight Principle*,
7. Criterion thirteen: *Feedback Loop Principle*, and
8. Criterion fourteen and fifteen: *Redundancy and Connectedness Principle*.

Criteria were clustered into the relevant principle of resilience they were derived from, as the various criteria were all derived from the principles of resilience as understood by the Stockholm Resilience Center and by the Wits program 'Urban Resilience Assessment for Sustainable Urban Development' (Harrison *et al.*, 2014; Biggs *et al.*, 2015; Haywood and Van der Watt, 2016). The clustering of the criteria ensured that the different criterion were not weighted equally, however the various principles were weighted equally. The clustering of criterion into principles was conducted by summing the constituent criteria and dividing that number by the number of criteria summed.

The interview data were consolidated, and the data were analysed using thematic content analysis techniques. That is the interview data were assessed as follows, transcripts were read and annotated to identify key words, phrases, or sentences. The data for each question were then categorized to ensuring coding of the data. This categorized data were then presented in several descriptive forms, which included bar graphs, tables and word clouds. Word clouds were generated using Wordle version 0.2. The word clouds were used to creatively represent text heavy questions. Officials are differentiated through the use of alphabets, that is as

follows Official A, or Official B, to comply with the ethics process that was followed. It should be noted that the evaluation of the interview data did not take any personal relationships into account, based on my time as an intern at the CoJ.

The scorecard used for both components of this study, that is both the policy analyses and the interview process both incorporated were developed based on the CSIR's 'Building Resilience into Business Strategy, Management and Reporting' template (Haywood and Van der Watt, 2016) and included the key principles of resilience as identified in the literature (see Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016). The data derived from the policy analyse and the interview process will be explored in the next chapter.

Chapter 4: Results

In this chapter the research findings and results, structured around the objectives of this study, are presented. The research findings are laid out in the same order as the objectives they address. As discussed in the methodology section, this study consisted of two parts for data collection, both of which are qualitative. The first part involved a document content analysis that was used to address objectives one and two. The second part involved semi-structured interviews and was used to address objective three.

4.1 Analysis of the CoJ's key strategic documents

The City of Johannesburg's strategic documents were evaluated to determine the extent to which climate change resilience planning is incorporated in the City's strategic documents, which in the context of this study, are the *Growth and Development Strategy (GDS 2040)*, the *Integrated Development Plan (IDP) 2016-21* and *the IDP 17/18 Review*. All three of these strategic documents included concepts such as adaptation, mitigation, sustainable development and resilience, for example in the *IDP 2017-18 Review* the City details its adaptation and mitigation goals on page 66 which included amongst others, "*Enhance resilience of communities by adapting infrastructure*" (CoJ, 2018).
The scorecard assessment, which aimed to determine whether climate change resilience planning is incorporated in the CoJ, indicated that the City considered climate change resilience planning in the three documents assessed by this study (Figure 4). Climate resilience planning was considered in all three documents assessed with all three documents scoring higher than 59% (Total score of the document, converted to a percentage Table 3). Thus, all three documents reflected more than fifty percent of the principles of resilience as assessed by this study (Table 3). The *IDP 2016-21* (Table 3) had the highest score of the three documents assessed.

Table 3. Total score given for the *GDS 2040, IDP 2016-21* and *IDP 17/18 Review* (out of 24)

Document	Total Score	Percentage
GDS 2040	14.33	59.71%
IDP 2016-21	15.5	64.58
IDP 17/18 Review	14.17	59.04%

While all documents incorporated the principles of resilience planning, the extent to which the principles of resilience were incorporated differed significantly as seen (Fig. 3). The CoJ's strategic documents, for example considered the Equality Principle completely, with all three documents scoring three out of three for these principles. The three policies all indicated that the CoJ monitors income disparity and inequality within the City and have developed solutions to reduce inequality and income disparity within the City. The CoJ, for example, in the IDP 2016-21 made inequality its priority and the cornerstone of the IDP as articulated on page 9 "*As the City, we have translated these four outcomes into 11 priority implementation plans that will assist us to address our challenges of poverty, unemployment and inequality*" (CoJ, 2016a).

The CoJ's strategic documents, however, did not consider the Environmental Feedback Loops Principle, with all three documents scoring zero out of three for this principle. The documents were scored zero out of three as there was no indication that the CoJ evaluates the impact of its environmental feedback loops, for example, there was no indication that the City utilises ecosystem-based monitoring or any other feedback loop monitoring systems (Ims and Yoccoz, 2017). The Environmental Feedback Loops Principle evaluated the extent that the CoJ monitors and manages environmental feedback loops that can either reinforce or dampen change, i.e., a feedback loop can either be positive or negative (Chapter 2.2; Appendix 1; Biggs *et al.*, 2015).

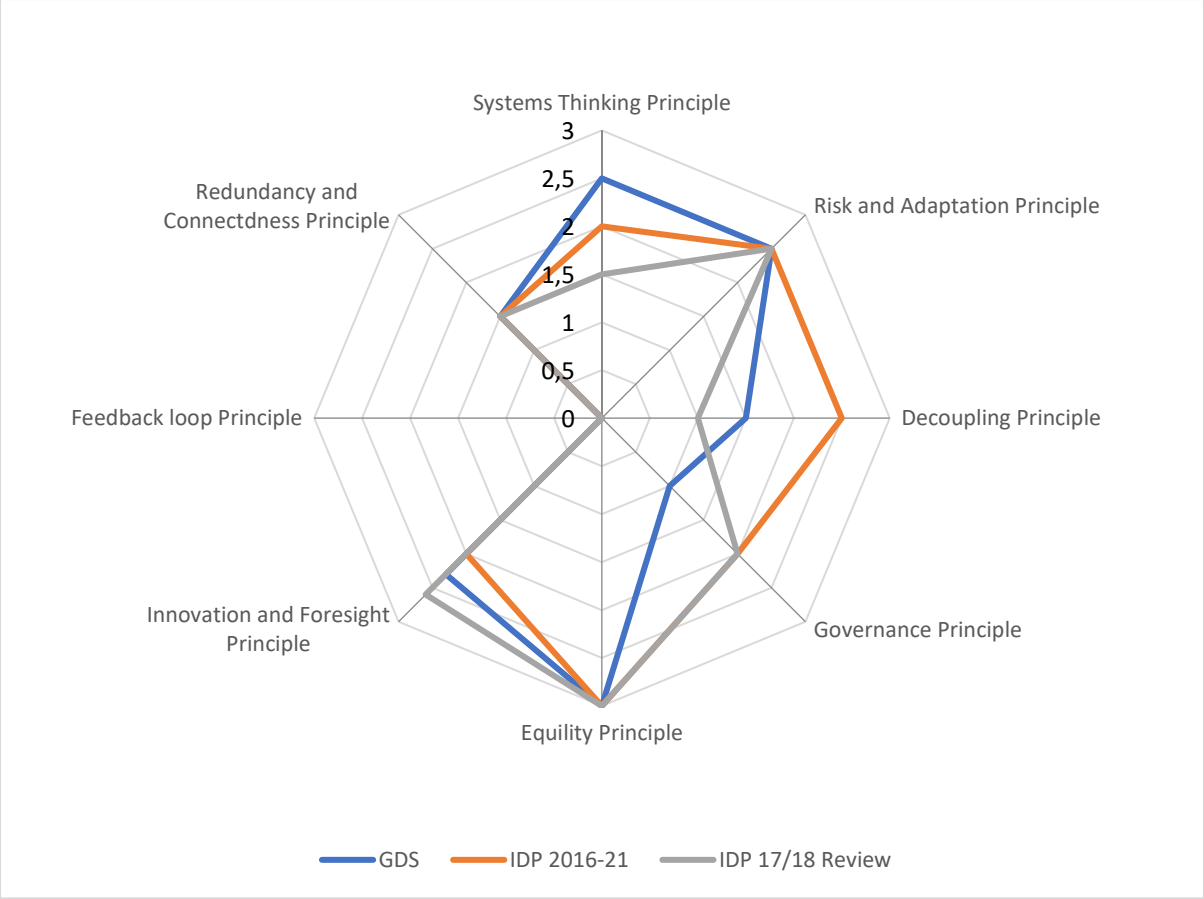

Figure 3. Scorecard assessment into the City of Johannesburg's strategic documents

Some similarities were noted particularly in terms of the manner in which the principles of resilience were incorporated in the three documents assessed (Fig. 3). An example of similarities in the way the principles of resilience were incorporated is the Risk and Adaptation principle where all three documents scored the same (2.5 out of 3). Each of these documents accounted for expected and current risks and that are both immediate and long-term risks. Furthermore, each of the documents accounted for financial, social, and environmental risks. However, while the CoJ has measures in place to mitigate its risk register, measures to enhance the adaptive capacity of the City were not discussed in substantial detail.

It should be noted that the City took different methods of documenting risks and the management thereof in its strategic policies. The *IDPs*, for example, have dedicated a section to risks and disaster management (Chapter 17 in the IDP 2016-21 and Chapter 7.4.4. in the IDP 2016-21). Whilst the *GDS 2040* does not have a section dedicated to risk and disaster

management the document does include the long-term and short-term risks that affect the City, for example on Page 6 in the *GDS 2040* the document describes the risk of globalisation, specifically "*Financial risk and contagions spread quickly through this interconnected system*". The *GDS 2040* furthermore commits the CoJ to building resilience to climate change, for example on page 96 the GDS mentions that the City "*will focus on building its resilience to climate change. Interventions that address both climate change adaptation and mitigation will be necessary and will be implemented*" (CoJ, 2011).

Notwithstanding some overlaps, the assessment also indicated that there were differences in the manner in which the principles of resilience were incorporated in the three documents assessed by this study (Fig. 3). The *Systems Thinking principle*, is an example of this, with each document scoring differently (Fig. 3). A preliminary assessment as undertaken in this study reveals *some attempts* of systems thinking in the City. Systems thinking, however, is a very 'complex' approach (Biggs et al., 2015; Ballew *et al.*, 2019) and is not fully explored in this assessment and requires much more focused assessment. The *GDS 2040* was given a score of 2.5 for this principle as it showed accountability towards reducing government's impact on the environment and was developed utilising systems thinking. The *GDS 2040* understands the interlinked system of people and nature and that change in one component would affect other components. Chapter 2.5.2 is an example of systems thinking and how the CoJ manages economic growth, whilst considering the environment and society. Chapter 2.5.2 in the *GDS 2040* is titled, "*Resilience, sustainability and liveability: Implications for economic growth*" (CoJ, 2011: p. 25). The *IDP 2016-21* received a score of 2 for the systems thinking principle, as it did not achieve the same extent of holistic environmental thinking that the *GDS 2040* had achieved. Priority 1, for example, while it touches on the societal aspect of systems thinking completely ignores the environmental component, "*Economic growth, job creation, investment attraction and poverty reduction*" (CoJ, 2016a: p. 9).

The *IDP 2016-21* incorporated the principles of resilience to a greater extent in more instances than the *GDS 2040* and *IDP 17/18 Review* did. As it achieved the highest score in a principle of resilience in more instances than the *GDS 2040* or the *IDP 17/18 Review*. It should be noted that certain principles of resilience, like the Decoupling Principle, scored higher in the *IDP 2016-21* than in the *GDS 2040* but then scored lower in the *IDP 17/18*

Review. The Decoupling Principle, for example, scored 1.5 in the *GDS 2040*, 2.5 in the *IDP 2016-21* and 1 in the *IDP 17/18 Review*.

The change in perspective on the decoupling principle between the *IDP 2016-21* and the *IDP 17/18 Review* can be seen in the manner in which the respective policies viewed the Green Economy. The *IDP 2016-21* included a key performance indicator (KPI) on the green economy, whilst the *IDP 17/18* Review does not. However, while the *IDP 2016-21* includes a KPI on the green economy, it is drafted in a vague manner, as indicated in figure 4 below.

The CoJ has a clear standing on the inequality that exists within the CoJ, with all three policy documents scoring 3 out of 3 for the equality principle. All three documents indicate that government monitors income disparity and inequality in the CoJ and is actively addressing income disparity and inequality. The chapter on demographics in the *IDP 2016-21*, is an example of the monitoring of these data (CoJ, 2016a: p.12-15). Furthermore, all four outcomes of the *GDS 2040* indicate the CoJ is planning or is actively addressing inequality and income disparity (CoJ, 2011: p. 9).

Table 39: PRIORITY 3: GREEN AND BLUE ECONOMY

NATIONAL OUTCOME: ENVIRONMENTAL ASSETS AND NATURAL RESOURCES THAT ARE WELL PROTECTED AND CONTINUALLY ENHANCED														
JOBURG 2040 OUTCOME 2 & 3: A SUSTAINABLE CITY WHICH PROTECTS ITS RESOURCES FOR FUTURE GENERATIONS AND A CITY THAT IS BUILT TO LAST AND OFFERS A HEALTHY, CLEAN AND SAFE ENVIRONMENT. OUTCOME 3: AN INCLUSIVE, JOB-INTENSIVE, RESILIENT AND COMPETITIVE ECONOMY THAT HARNESSES THE POTENTIAL OF CITIZENS'.														
	IDP PROGRAMME 3: GREEN AND BLUE ECONOMY													
KPI No	**Strategic objective**	**Key Performance Area**	**Key Performance Indicator**	**Interventions**	**Baseline 2011/16**	**2016/21 Target**	**2016/17 Target**	**2017/18 Target**	**2018/19 Target**	**2019/2020 Target**	**2020/21 Target**	**Lead Cluster**	**Lead Department**	**Supporting departments**
9	To grow the economy with less negative impact in relation to climate change and pollution	Green technology	% implementation of the consolidated green economy implementation plan	Green buses, eco-mobility programme, solar geysers and water infrastructure	50% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	100% implementation of the green economy implementation plan	Economic Growth	Economic Development	Environment, Infrastructure and Service Delivery, City Power, Johannesburg Water, Metro Bus and Transport

Figure 4. Key Performance Indicator on the Green and Blue Economy, Integrated Development Plan 2016/21 (CoJ, 2016a)

It is important to note that while the *IDPs* and the *GDS 2040* were assessed in comparison to each other in the paragraphs above, the *IDPs* are complimentary to the *GDS 2040*, and therefore certain aspects need to be raised holistically. The Governance Principle is an example of the importance of viewing these documents holistically, with the *GDS 2040* getting a score of one while the IDPs both got scores of 2. The *GDS 2040* for instance does not describe the governance structure of the City as required by criterion seven, as governance is intentionally excluded, "*Furthermore, this strategy does not describe institutional powers, functions and operational activities*" (CoJ, 2011: p. 8). Thus, viewing an *IDP* and the *GDS 2040* collectively may provide an understanding of the governance structure of the CoJ and the manner in which public participation occurs within the CoJ. The CoJ's policy documents viewed, for example, indicate that governance is being considered as required by resilience thinking, with the CoJ utilising a combined 'top down' and 'bottom up' structure**.** The *IDP 201621* covers the governance process in substantial detail and includes organograms which indicate the 'top down' governance structure (Fig. 2, chapter 2.6) (CoJ, 2016a: p. 34-43). The *IDPs* also indicated the manner in which public participation and the 'bottom up' approach to governance that occurs in the City, however the *IDP*s indicate public participation is relatively limited and does not indicate whether they hinder decision making processes. Cluster Community Conversations, for example, which is an initiative that focusses on mobilising communities to become active citizens, has to take place as part of the *IDP* process to help ensure that communities help craft their developmental futures (CoJ, 2016: p. 40).

The CoJ included climate change to a significant extent in each of the strategic documents assessed. Each document included a chapter on the topic, for example in the *IDP 17/18 Review* chapter 1g discusses climate change adaptation and mitigation in the CoJ. Furthermore, the CoJ also discusses the importance of innovation to the City by making reference to its participation in knowledge sharing bodies including SALGA, C40 and ICLEI to name a few (CoJ, 2016a: p.51). The CoJ also indicates that it is abreast with innovation in technology, by discussing the implementation of smart meters, widespread access to free internet and the implementation of the smart city plan (CoJ, 2016a: p.10). However, whilst the City implements innovative solutions, there is no indication in any of the policy documents assessed that it funds innovation within the CoJ.

The CoJ's key strategic documents, finally, overall incorporated resilience to a similar extent (Table 3), however, with specific principals of resilience, there were differences in the way they were considered (Fig. 3). The *IDP 2016-21* and the *IDP 17/18 Review*, for example, differed on three principles, which are the Innovation and Foresight Principle, Decoupling Principle, Governance Principle and Systems Thinking Principle.

4.2 Assessment of the CoJ's policy documents related to water

Having presented the results of the assessment into the City's strategic document in the previous section, this section of the study analysed the City's policy documents that are relevant to water management. The scorecard assessment into the City's plans and policies that are relevant to water management indicates that the extent to which the City incorporated the principles of resilience thinking into these plans and policies differed significantly. The average score across the six documents assessed by this study was 14.91 (SD 4.49). Table 2 indicates that, based on the scorecard assessment, Johannesburg Water's *Water Conservation and Water Demand Management: Framework Strategy* had the highest score, while the Johannesburg Road Agency's *Strategy 2017* had the lowest score (Table 4; Figure 5).

Table 4. Total score given for the City's policies relevant to water management (out of 24)

Document	Total Score	Percentage
Sanitation Policy for the City of Johannesburg 2002	10.83	45.13%
Integrated Environmental Management Policy 2005	16	66.67%
Catchment Management Policy for the City of Johannesburg 2009	18.83	78.47%
Water Conservation and Water Demand Management: Framework Strategy 2010	19.83	82.64%
Disaster Management Strategic Action Plan 2016	16.83	70.14%
Johannesburg Road Agency Strategy 2017	7.16	29.86%

The scorecard assessment into the City's policies relevant to water management (Table 4; Fig. 5) indicates that Johannesburg Water's *Water Conservation and Water Demand Management: Framework Strategy 2010* not only scored the highest cumulatively, but it also incorporated the principles of resilience to a greater extent than any other policy paper, by scoring the highest or joint highest in the various principles assessed. The Johannesburg

Road Agency's *Strategy 2017* not only scored the lowest cumulatively, but it incorporated the principles of resilience to a lower extent compared to the policies assessed, as it scored the lowest or joint lowest in the various principles assessed.

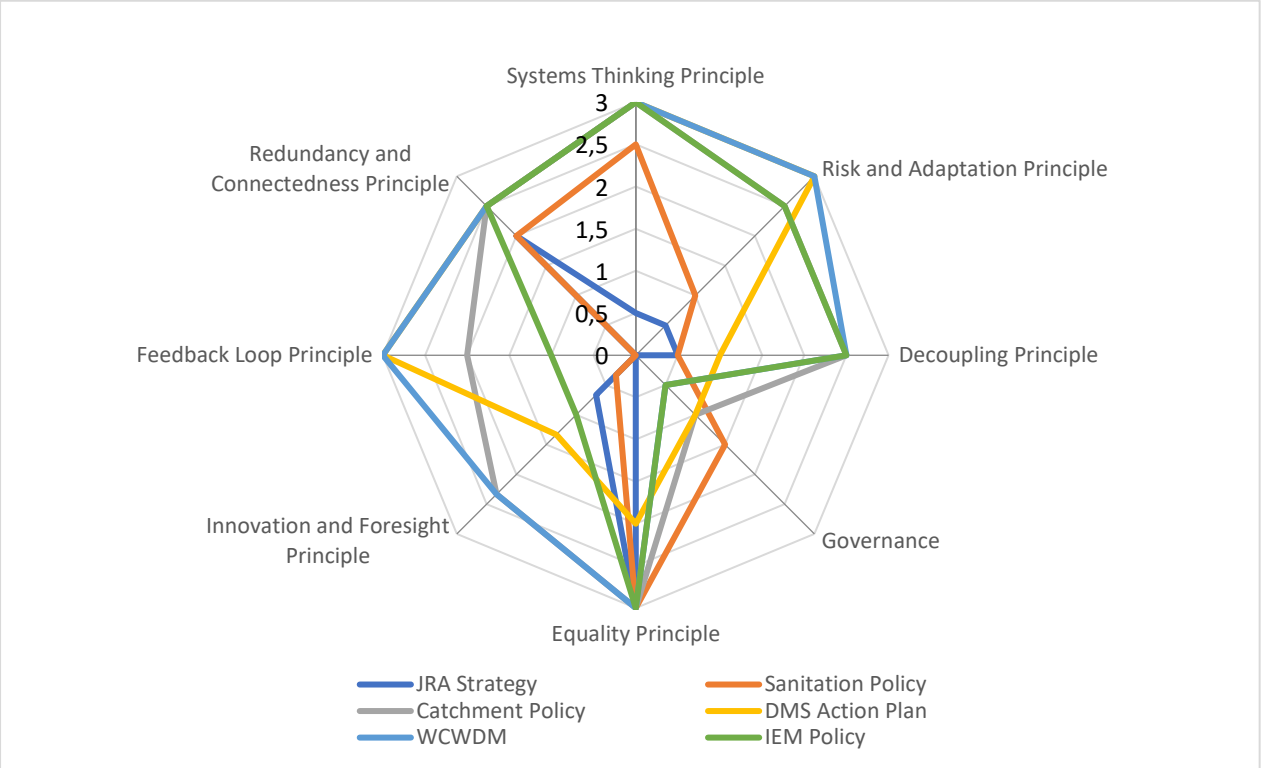

Figure 5. Scorecard assessment into the City of Johannesburg's water management policies

While attempts to evaluate whether the inclusion of the principles of resilience in documents increased over time was not possible, as can be seen in Table 4 and Fig. 5 respectively. Based on the literature review, specifically a study by Peyroux which indicated that the concept of resilience was formally introduced into the CoJ's planning discourse, a comparison of documents promulgated before the *GDS 2040* was published compared to documents promulgated post the *GDS 2040* was conducted. This comparison indicated that the two documents promulgated after the *GDS 2040* scored on average 49.98 percent in comparison to 68.22 percent for the four documents promulgated before the *GDS 2040* (Table 4).

The City's water management policies scored on average similarly to the City's strategic documents (*IDPs* and *GDS 2040*), 14.66 out of 24 (strategic documents) in comparison to 14.91 out of 24 (water management policies). As in the strategic documents, the importance of the Principle of Equality in the City is clear even within the water management space, for example in the *Water Conservation and Water Demand Management: Framework Strategy 2010* the importance of ensuring equitable solutions to water management challenges is

clearly articulated across the entire document, "*It is noted that various of the proposed intervention measures should be targeted at different socio-economic groups across the city, as this will yield the most effective results both from a cost and water savings point of view*" (JW 2010: p. 87). The *WCWDM* makes mention of several measures that have been implemented including the way the City's water tariff structure ensures equality and income disparity is managed, for example all citizens are provided with 6 kiloliters of free water per month and the water tariff structure ensures that higher-income areas pay more than lower-income areas (JW 2010: p. 19-21).

The CoJ's water management policies overall incorporated climate resilience planning with an average score of 62% across the six documents assessed, however the *Johannesburg Road Agency's Strategy* and the *Sanitation Policy for the City of Johannesburg 2002* scored lower than 50%. The key issues that emerged from this section is that policy is not updated regularly and that planning concepts that have become a part of the planning discourse within the City are not introduced across the entire City. In the *Johannesburg Road Agency's Strategy*, for example, resilience was limited to resource resilience and financial resilience in comparison to the *GDS 2040* where resilience was made the key concept of that document (CoJ, 2011; JRA, 2017).

4.3 Interviews

A series of interviews (five) were also conducted with some senior officials from several departments and MOEs, to ascertain to what extent the City officials are beginning to think about operationalizing resilience in their daily activities. These officials were drawn primarily from departments that are responsible for water management in the City of Johannesburg.

Three of the officials interviewed understood what climate change resilience was, officials made mention of phrases like 'bounce-back ability after an event (climate)', thus indicating that they understand some elements of climate change resilience. Official A, for example, gave the definition of climate change resilience to be "*Having a city that is able to function optimally even after being hit by an event"* the official then went on to use the example of *'Tokyo being hit by an earthquake and life in the City resumed very quickly after"*.

Climate change is regarded to be a risk to the CoJ by its officials, however, only one of the officials, Official D, interviewed considered climate change to be the primary risk for the CoJ (Fig. 6). The reason behind the lack of consideration for climate change as the primary risk to the City included more urgent issues like socio-economic challenges, with Official B making

it clear that it is "*humans before the environment*" for the City. Another reason given by Official A is that, because of the City's location (it is an inland city), it is protected from the one of the 'direct' impacts of climate change such as sea-level rise, and as a result climate change is not viewed as an immediate threat to the City. Official A did make it clear that climate change is viewed by the City as a long-term threat and as such it does not get the same attention as some of the more immediate threats.

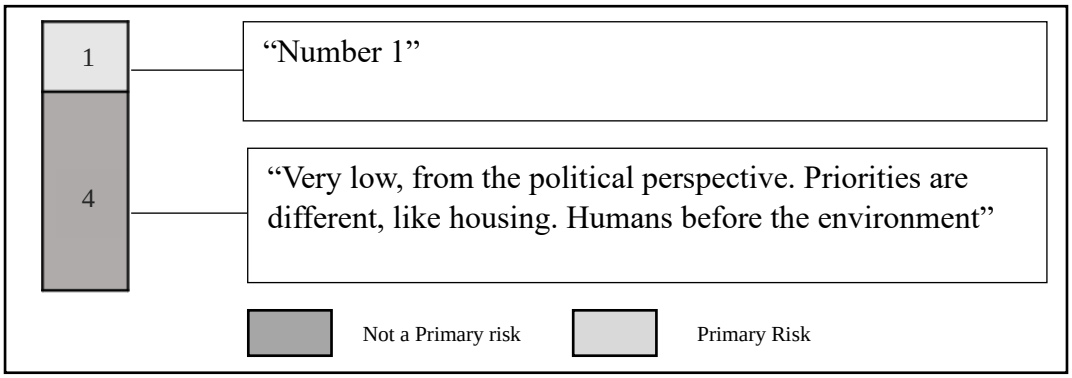

Figure 6. Number of officials that consider climate change to be a primary risk versus those that don't consider it to be a primary risk; includes a quote

Four of the officials interviewed gave examples of projects they considered to build resilience in the City towards climate change (Fig. 7), however the officials were clear that these projects were not designed for the purpose of climate change resilience but rather that the outcomes of a project were favorable for climate change resilience. Officials A and C are concerned that, although there are projects that show some elements of resilience, these projects are not developed at scale (Fig. 7), meaning that cumulatively these projects will not have an impact on the City's resilience to climate change and that these projects are "*hidden in corners*". Currently a more surface 'resilience' consideration is noted (see Fig. 7) with categories showing sectors being engaged but a more detailed investigation of resilience and systems thinking is required.

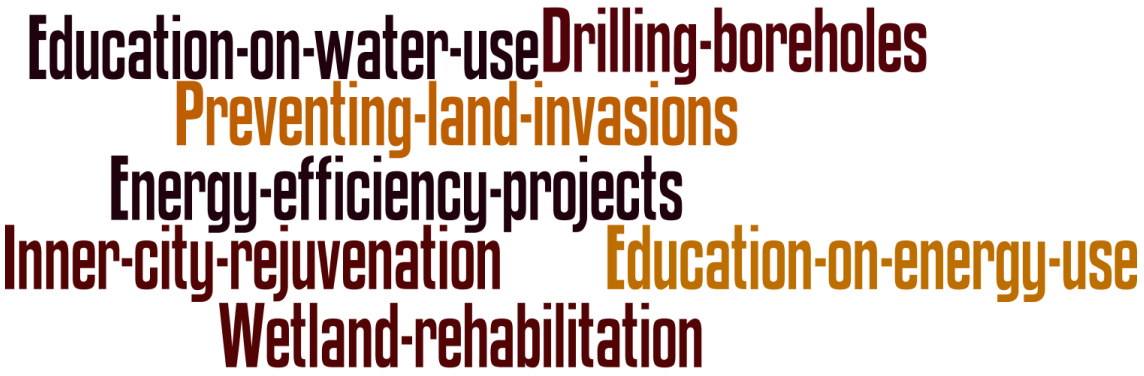

Figure 7. Word cloud of projects that officials believe contribute to resilience

All officials interviewed considered changes in administration as a negative factor impacting climate change resilience efforts in the City. The City was affected by a change in administration shortly before this study began (as discussed in chapter 2.7). The primary reason for this negative view was the effect on policy creation, officials mentioned that the change in administration resulted in a hard reset for policy creation. As different political parties have different priorities and these priorities are reflected in the policies they create. Additionally, officials mentioned that the change in administration has resulted in short-term policy making (all policy making) in order to placate voters and to win the electorate, this has impacted long-term strategic thinking. Officials working on climate change specifically mentioned that the change in administration affected climate change efforts negatively as Members of the Mayoral Committee (MMC) need to be educated on climate change and the change in administration resulted in a new tranche of MMCs all needing to be brought up to date on climate change efforts and climate work in the City.

While all officials interviewed believed public participation is important in policy creation, four of the officials interviewed felt that public participation in its present form is not helpful (Fig. 8). Officials indicated that public participation is not effective, as it is currently conducted as a '*tick box'* exercise, that is it is only done to ensure compliance, it is expensive to do properly and the way it is done currently allows public participation forums to be easily hijacked for political purposes. One infrastructure project, for example, that required public participation was hijacked by a political party to demand work for the local community.

Official B indicated that political parties hijack public participation forums in order to develop or grow their constituencies.

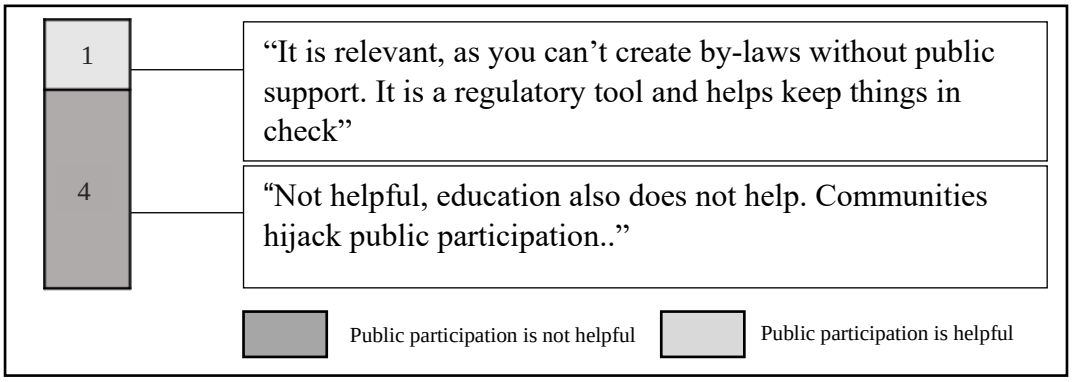

Figure 8. Number of officials that considered public participation is helpful versus those that do not consider it to be helpful; includes a quote of interest. N=5

All the officials interviewed indicated that the City allows for officials to learn and enhance their knowledge of climate change by funding attendance of officials at university courses and allowing officials to attend conferences. One grievance that emerged was the lack of knowledge sharing between departments, specifically information on lessons learnt from the implementation of projects or processes. Four of the officials interviewed believe that the City does not allow individuals to innovate within departments, i.e., innovation that improves the functioning of the department, some of the methods that inhibit innovation in the City (Fig. 9). Official D did indicate that, while innovation is hindered in the City, the City does have pockets of innovation for example the CoJ was the first city in South Africa to roll out a Bus Rapid Transport system and Green Bonds.

Figure 9. Word cloud of inhibitors to innovation in the City

For the City of Johannesburg to deliver services successfully, the City operates as regions which are intended to improve service delivery. The regions, as discussed in chapter 2, divide the CoJ into operational areas to enhance service delivery (Fig. 1, Section 2.7). With regards to whether these regions can function independently of the core, i.e., the core in this case is the City's management and support functions, for example human resources. Two of the officials interviewed were of the opinion that the City's regions could survive independently of the cores and the associated support functions it provides. Two other officials interviewed believed that the regions do not serve as intended, with an official stating that the regions have not served their function, as the regions have not enabled decentralisation and are overly reliant on the core for support. Official C interviewed did not have enough information, as they have not worked with officials from the regions or worked in a region, to have an opinion on this facet of the City (Fig. 10). All officials interviewed agree that, if the City implements the Regions as intended, service delivery will improve in the City of Johannesburg (Fig. 1, Section 2.7).

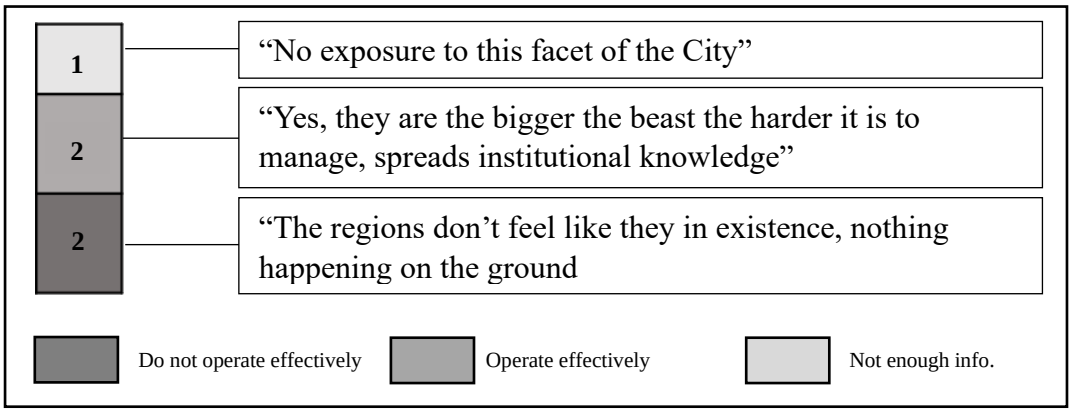

Figure 10. Number of officials that believe that the City's region operating model is being delivered successful versus those that do not; includes an interesting quote. N=5

All the officials interviewed believe there is redundancy and diversity in dealing with challenges in the City, for example the South African Police Service and the Johannesburg Metro Police have some overlapping responsibilities, thus ensuring redundancy and diversity in dealing with challenges. Officials, however, felt that for the most part, the fact that the City has diversity built into the system affects the City negatively, for there is a "blame game when things go wrong", and the lack of communication between departments affects the effective delivery of services and results in fruitless expenditure. An example given was the

Johannesburg Road Agency had just completed resurfacing a road and shortly after the completion of the project, Johannesburg Water proceeded to replace water infrastructure under that road, thus damaging the road. Official B mentioned that this could have been avoided if Johannesburg Water and Johannesburg Road Agency communicated with each other or if they were one department.

Three of the officials interviewed did not use climate change policy in their own planning and policy creation. Unsurprisingly, the two officials that have used climate change documents used these policies because they formulate climate change strategy. Officials that do not use climate change policy indicated that they use the knowledge they gained in various workshops and forums in their own plans and policy. Official E made mention that EISD hosts a climate change forum every quarter which provides valuable insight and knowledge sharing on climate change issues.

The interview process also brought to attention several interesting observations about the City, including the following:

(1) the effect that climate change workshops have on policy creation and implementation,

(2) whilst climate change resilience theory considers redundancy to be important, City officials dislike redundancy as its effect on accountability is detrimental,

(3) public participation is complicated and needs to be rethought in the context of South Africa and finally,

(4) projects are being implemented in the City that enhances the resilience of the City towards climate change, however this is not due to climate change pressures.

The CoJ within the policies (both strategic and water management policies) assessed included the principles of climate resilience. Based on the inclusion of the principles of climate resilience, most of the policies assessed could be considered to be climate resilient. The assessment found that the inclusion of principles of resilience was not necessarily because of the use of resilience discourse in the planning process.

There are several key issues that emerged from this assessment, (1) the way systems thinking in the City addresses the social component of systems thinking in comparison to the environmental component, specifically at the IDP level. (2) Policy is not updated regularly and planning concepts that have become a part of the planning discourse within the City are not introduced across the entire City. (3) the effect of education on climate awareness in the

CoJ and (4) resilience projects are implemented in the City and not because of climate change but because they sense for other purposes. These key issues will be explored in greater detail in the discussion chapter to come.

Chapter 5: Discussion

The effects of climate change that are occurring now both globally and locally in the form of extreme rainfall events, tropical cyclones and heat wave conditions, amongst others, are projected to become worse in Southern Africa unless immediate action is taken (Bulkeley, 2013; Collins *et al*., 2013; Hoegh-Guldberg et al., 2019). Globally governments are aware of the risks of climate change and have developed strategies and plans to deal with climate change (Bulkeley, 2013).

Government strategies and plans now utilise concepts like adaptation, mitigation, sustainable development and more recently resilience planning. Climate change resilience planning has emerged in recent years as the next phase of sustainable development to provide new perspectives on development in a changing world (Leichenko, 2011; Davoudi *et al.*, 2012). Over the past few years, the concept has gained a central place in spatial planning, both globally and in South Africa (Harrison *et al*., 2014). In light of this, the aim of this study was to assess the extent to which the South African local government is beginning to embed resilience to climate change planning in policy.

In the discussion that follows the following objectives are examined:
(1) the extent to which climate resilience planning is incorporated in strategic policy and planning in the City of Johannesburg, (2) the extent to which climate change resilience planning is incorporated in policies and plans relevant to water management in the City of Johannesburg and (3) the extent to which climate change resilience planning is practically implemented in the City of Johannesburg.

5.1 The extent to which climate resilience planning is incorporated in strategic policy and planning in the City of Johannesburg

The study has investigated the extent of climate change resilience planning in the City of Johannesburg. As anticipated, the City like its global counterparts, has included concepts like adaptation, mitigation, sustainable development and resilience planning in several strategic documents.

The CoJs strategic documents that were assessed were either complementary or updated documents, i.e., the IDPs are complimentary towards the *GDS 2040* and the *IDP 17/18 Review* was an updated iteration of the *IDP 2016-21*. Although these strategic documents

informed each other, in some instances there was a decline in the extent to which a principle of resilience was incorporated, from an earlier policy to a later policy, for example, from the *GDS 2040* to the *IDP 2016-21*. This could potentially indicate that the City's policies are driven by individuals or political priorities rather than by strategy and planning principals, for example, utilising resilience theory as a policy development tool. The impact of policy driven by individuals will be discussed further in sections 5.2 and 5.3.

The complimentary relationship of the CoJ's strategic documents warrants a holistic view of the City's strategic landscape. Thus, the documents will be discussed as a collective rather than individually. The City has designed its strategic documents to be viewed holistically and it is thus important to consider them holistically (CoJ, 2011: p. 7).

In the context of this study "the system" is the City of Johannesburg's socio-ecological system and is being interpreted as a more holistic assessment of these components rather than a detailed investigation of complexity science and systems thinking (Biggs *et al.*, 2015; Ballew *et al.*, 2019). City officials, however, seem to consider the system to be primarily socio-economic (as per the interview process). This may suggest that there is dissonance between what academics consider to be a 'system' (Bai *et al.*, 2018) in comparison to what officials in the CoJ consider a 'system' to be. The City of Johannesburg's strategic documents reinforce this dissonance, for instance while the City considers in its policies the environment, society and the economy, when considering the environment, the City considers it within silos. It should be noted that the societal component of systems thinking was embedded throughout the *IDPs* and the *GDS 2040*, as per the systems thinking approach to planning (as per the policy analysis, chapter 4.1).

Public and private sector organisations are often comprised of bureaucratic structures that are designed to structure processes and allocate people, thus ensuring an effective and efficient organisation. These bureaucratic structures have been described in management literature as silos (Stone, 2004; de Waal *et al.*, 2019). While originally designed to ensure an effective and efficient organisation, it has been found that silos have had a detrimental impact on collaboration and cooperation within an organisation (de Waal *et al.*, 2019). In fact, a survey on collaboration in corporates, indicated that silos exist in 83 percent of respondent organisations and 97 percent of respondents said that silos have had a negative impact on their organisations specifically impacting collaboration (de Waal *et al.*, 2019).

The impact of silo mentality is felt particularly when dealing with cross-cutting issues like climate change, which require support from all functions in the City, for example, if a City's Economic-development department focused only on economic development above all else and without regard for socio-ecological sustainability the City will be negatively impacted. Studies indicate that when environmental conditions weaken a city's ability to retain and attract the best people the overall aims of the strategy in the City will be affected (Anguelovski *et al*., 2018; de Waal *et al.*, 2019). These studies highlight the importance of enhancing cross-functional collaboration, as failure in one department can cascade into something more significant. The CoJ's itself has experienced the failure of managing cross-cutting issues like crime and poverty, which decimated the City's Central Business District (CBD) and resulted in many corporate centres moving from the CBD to Sandton which then affected other businesses in the CBD and has accelerated its decay (Winkler, 2013).

The CoJ does, however, considers the impact it has on society across all areas, for example when the environment is discussed, the discussion include the societal benefits of a healthy environment (see Chapter 4.1; CoJ, 2011: p.64-65). Likewise, when the economy is discussed, the societal benefits of that economic focus area is discussed as well (see Chapter 4.1). This could indicate that City only engages in silo thinking when dealing with the environment and climate change. Perhaps the *IDP* process, which is people centric, ensures that the societal aspects of the City are holistically included (Thebe, 2016).

An important component of a more integrated approach in climate climate change action is risk management (Bai *et al.*, 2018). Globally there is consensus that risk awareness, particularly in terms of climate risks, is important today but will only become more important and valuable in the future (Braumann *et al.*, 2020). The City of Johannesburg effectively indicates and articulates the risks and challenges that affect the City, which range from societal challenges (inequality) to environmental challenges (waste management). The City is less effective, however, at indicating how it plans to adapt to these challenges in most instances including the links to climate variability and change. The City specifically struggles with articulating how it is dealing with cross-cutting issues like climate change, for example the City does not indicate how it will adapt to changing environmental conditions which will affect inequality and the City's infrastructure. The recently released CAP (March 2021), will hopefully began to address some of these concerns, however it should be noted adaptation and mitigation plans have been previously developed in the City of Johannesburg without being effectively implemented (Hetz, 2016; CAP, 2021).

The City of Johannesburg very clearly articulates the impact that it is having on the environment and to a limited extent indicates how it intends to reduce its impact on the environment (Chapter 4.1). However, the City does not explain how it intends to decouple its current economic growth pathway from resource use. The City of Johannesburg is one of the largest contributors to green-house gas emissions on the continent, emitting upwards of 27.2 million tonnes of CO_2e annually and the City is also a producer of vast quantities of waste, 1.8 million tons annually (CAP, 2021). This makes the lack of plans of decoupling growth from resource use a matter of serious concern. Decoupling economic growth from resource use is one of the most critical priorities for climate resilience and sustainable development (Wiedmann *et al.* 2015). Globally cities have started to decouple economic growth from resource use. The City of Chongqing, in China, for example, managed to substantially decouple its economic growth from resource use by aggressively improving its policy regulations on energy and environmental issues (Yu *et al.* 2017). The CoJ should engage with its international peers to ensure that the CoJ can fast track its decoupling of economic growth from resource use.

The City does, however, make mention of a Gauteng green economy strategy in the IDPs assessed, however discussions around the implementation of this document are limited to the *IDP 2016/21* and are mentioned in passing in the *IDP 17/18 review*. This could suggest that the manner in which economic growth was viewed in the City changed when the Democratic Alliance led coalition took control of the City in 2016. The *IDP 2016/21*, for example, included a Key Performance Indicator for the Green Economy (Figure 4), which suggests that the City made the Green Economy a priority. There is no KPI for the Green Economy in the *IDP 17/18* Review.

The usefulness of the Gauteng green economy strategy even within the *IDP 2016/21* can however be called into question, considering that the City was also promoting manufacturing and the re-industrialisation of Johannesburg. Additionally, the targets of the KPI (Figure 4) are vague, hence the importance of the Green Economy to the City of Johannesburg can be debated. The City of Johannesburg's policy seems to follow a similar trajectory to what Death found in his study on South Africa's commitment to the the Green Economy, i.e., it looks good on paper but difficult and unlikely to be implemented (Death, 2014). South Africa's Green Economy Policy at the national level has been described by one think tank as world leading, as South Africa has sought to project a brand of being a global leader in sustainable development (Dual Citizen, 2012). The country, however, falls well short of the

United Nations Environment Programme definition of a green economy, as our economy is dependent on fossil fuels and minerals extraction (UNEP, 2011). Studies show that South Africa's overall commitment to the Green Economy is shallow and incoherent and has limited potential to drive economic growth (Death, 2014).

Decoupling economic growth from resource use needs to be conducted in a responsible manner, to ensure that there are not societal implications of this transition. The effects of an unequal society are far reaching and includes social challenges as well as environmental challenges, like the burning of fossil fuels and habitat destruction (Mikkelson *et al*., 2007; Dorling and Jones, 2017). The City of Johannesburg, as per the assessment undertaken in this study, understands the demographics and socio-economic development in the City, with the City's datasets providing data such as the age structure of the City and employment levels amongst others (CoJ, 2016a). The City appears to understand the extent to inequality in the City and has the necessary data sets to develop regional based initiatives to tackle the inequality that exists within the City (CoJ, 2016a: p. 15-20). Understanding and developing measures to reduce inequality is crucial in improving resilience to climate change, as several studies have noted that climate change impacts affects the poor, more than the rich and that climate change exacerbates inequalities (Skoufias, 2012; Islam and Winkel, 2017). Understanding the inequality that exists within Johannesburg, ensures that hypothetically in the event of a climate catastrophe, the necessary support will reach the right places (Islam and Winkel, 2017).

While the City, in the strategic policy documents assessed by this study discusses the risks that it faces, it does not indicate how it monitors and evaluates the slow variable and feedbacks that underpin these risks, for the most part, elements that are key when adopting a system's approach (Gallopin, 2006; Biggs *et al.,* 2015; Ballew *et al.,* 2019). The City, for example, discusses air quality and the impact it can have on health conditions specifically respiratory illnesses. The City, however, does not discuss whether it is monitoring air quality and assessing whether there is an increase or decrease in respiratory diseases as a result of diminishing or improving air quality (CoJ, 2016a). The lack of a more systematic approach in monitoring and evaluation has a direct impact on the ability of the City to proactively manage its socio-ecological system. This can lead to the City, only being able to reactively respond to challenges that may arise. Reactively dealing with challenges causes significantly more economic and social losses than proactive management, as the Netherland's Delta Program showed (Zevenbergen *et al.,* 2018)

Innovation can help to develop solutions to manage the risks and challenges that cities face (Clapp and Pillay, 2017), thus some have suggested that an innovative city is a resilient city (Biggs *et al.*, 2015). The City of Johannesburg's strategic documents state that the City strives to be innovative and mentions innovation throughout (Chapter 4.1). The City is abreast of change globally, for example the City of Johannesburg was the first city in South Africa to have a bus rapid transit system (Klopp *et al*., 2019), which indicates that the City understands the global innovation space and is learning from its global peers. While the City has implemented innovative ideas in the local context (Clapp and Pillay, 2017), the City as per as its strategic policies does not seem to be fully supporting innovation in the City. There is no indication of funding for innovation within the strategic documents assessed. The need for cities to be centres of innovation is understood to be important to broad resilience, as cities are where the majority of societal challenges emerge, as much of the global populace live and work in cities (Lewis *et al*,. 2018). Cities around the world including the global south are establishing innovation departments, including South African cities, for example, Cape Town established a tourism innovation network to increase the resilience of its tourism sector (Booyens *et al.*, 2018; Pojani and Stead, 2018). The CoJ should follow international best practice and establish innovation networks to manage climate change and other emerging challenges for the City.

The impact of funding for innovation will affect the CoJ's ability to find solutions for Johannesburg specific challenges It should be noted that while there was no indication of innovation support in the CoJ's strategic documents, the City is part of several knowledge sharing networks including SALGA, C40 and ICLEI to name a few (CoJ, 2016a: p.51). This can potentially mitigate the impact of the lack of potential innovation funding within the CoJ (CoJ, 2018; Abubakar *et al.*, 2019). As knowledge sharing is essential for an organisation to achieve success, as it enables innovation, facilitates improved decision-making ability and reduces the risk of failure (Abubakar *et al.*, 2019).

The City develops its policies with the assistance of numerous stakeholders, including national and provincial government, big business, and local communities (CoJ, 2011). The City has a good strategic cadence with a long-term strategy of 20 years which is the GDS, medium-term strategies of 5 years which are the IDPs and yearly strategies which influence service delivery called the Business Plan which are detailed plans for departments and municipal owned entities (CoJ, 2011; CoJ, 2018). In addition to having good strategic cadence, the City is self-sufficient in policy creation, as it develops policy independent of the

other spheres of government as enshrined by the constitution (Bénit-Gbaffou, 2018). This policy is developed holistically, i.e., not in a vacuum, but rather as Johannesburg specific policy that draws upon what is developed by national and provincial governments (CoJ, 2011). The ability to create Johannesburg specific policy, provides Johannesburg with the ability to be agile and adapt to change. This is particularly important in dealing with emerging challenges like climate change (Bahadur and Tanner, 2014). The City is however not self-sufficient in terms of its resource use as a result of its location and the distribution of South Africa's water and energy resources (Hickmann and Stehle, 2017). The City is trying to improve its self-sufficiency levels but like most major cities around the world, this is an almost impossible task (Monstadt and Schmidt, 2019).

The City of Johannesburg is highly connected with multiple major roads and railway lines linking it to the rest of South Africa and several airports in close proximity linking it to the world (CoJ, 2016a: p.94-9). The City is also connected to the different spheres of government and the international community in its policies which draw inspiration from documents like the National Development Plan and the United Nations Sustainable Development Goals, amongst others (CoJ, 2011; CoJ, 2018). The connectedness of the CoJ is important for resilience to climate change and ensuring the City can speedily recover from the effects of an unfortunate climate event, for example, airlift is a major component to disaster relief operations (e.g. when extreme flooding events may occur) and the availability of airports in Johannesburg can facilitate major disaster relief operations (CoJ, 2016a; Weit *et al.*, 2018).

The City of Johannesburg in its strategic documents does not indicate that it embraces redundancy or has cross functionality in its functional areas. A theoretical example of cross-functionality would be the Johannesburg Roads Agency having the ability to perform repairs on water infrastructure. It should be noted that since the bulk of planning and management literature subscribe to the idea that redundancy reduces operational efficiency (Bendor, 2020), the City may also feel that discussing redundancy in a country with endemic levels of corruption and inefficiencies can send the wrong message. Resilience theory however, challenges this view as duplication enables a variety of responses to challenges and provides an important fail safe against system component failure (Nowell *et al.*, 2017). To illustrate the benefit of redundancy, the United States public health sector can be used as an example. Redundancy promoted accountability and transparency as a result of federal and judicial reviews of policy, which allowed mistakes to be corrected through redundant mechanisms (Khan *et al.*, 2018). Redundancy should not affect service delivery or cause delays in the

passing of important policy and plans, as that would be the antithesis of resilience (Nowell *et al.,* 2017).

The City of Johannesburg's strategic documents utilised several of the principles of resilience as understood by this study (Chapter 2.2). The City furthermore considers climate change in its strategic policies, as each document included a chapter on climate change. The literature review, in the research above, has made it clear that the principles of resilience, can enhance a city's response to climate change, ensuring the city is climate change resilient (Harrison *et al*., 2014; Biggs *et al*., 2015; Haywood and Van der Watt, 2016). While the City of Johannesburg's strategic documents have utilised the concept of resilience and climate resilience in some of its planning discourse, there are several shortcomings that need to be addressed, for example, the manner in which the City is decoupling economic growth from resource us that requires greater investigation. It should be noted that the City of Johannesburg's strategic documents, have to cover a myriad of topics and thus cannot include detail on every topic. While there is some progress and progress in the CAP in particular, the implementation of the CAP which is only now beginning will require that the CoJ give much more attention to the principles of climate resilience. Having discussed the assessment of climate resilience thinking in the CoJ's strategic policies, focus now shifts to the assessment of climate resilience thinking in the CoJ's water policy landscape.

5.2 The extent to which climate resilience planning is incorporated in policy documents that are relevant to water management

Having discussed some of the broad assessments of resilience thinking in the City the investigation of certain water policies and interviews has begun to shed possible directions of the need for greater resilience thinking as this section now shows. The City of Johannesburg's water management policies that were assessed included the principles of resilience in their design, with two exceptions the *Sanitation Policy for the City of Johannesburg 2002* and *the Johannesburg Road Agency's Strategy 2017*.

A study by Peyroux suggests that the concept of resilience gained prominence in the CoJ, during the GDS process (Peyroux, 2015). The concept of resilience was introduced into the CoJ's planning discourse during the development of the *GDS 2040.* The CoJ's adoption of the concept of resilience was supported by SACN, which had at that time (2011) themselves adopted resilience as an overarching analytical framework with which to build urban policy. The utilisation of resilience in the CoJ is from the evolutionary perspective, rather than the

engineering perspective, and revolves around building adaptive capacity in the City (SACN, 2011; Peyroux, 2015).

Based on the study by Peyroux, this study assumes that policies and strategies that were promulgated before that point did not include the concept of resilience, as a design principle (SACN, 2011; Peyroux, 2015). Six documents, four of which were promulgated before the *GDS 2040* and two of which were promulgated after the *GDS 2040* were investigated for this research (Chapter 3.1). The four documents that were promulgated before the *GDS 2040* scored higher than the two documents that were promulgated after the *GDS 2040*.

Three theories, explained below, shed some light on how policy is developed and how climate change and resilience may/may not be mainstreamed in the City. The first is that resilience planning is not, being fully mainstreamed into the planning discourse of the City post the promulgation of the *GDS 2040.* The second, is that the City potentially incorporates resilience planning in some of its policy by accident and not by design and finally, there are shortcomings to Peyroux's study and therefore the assumptions of this study, that is Climate Resilience Planning in the City of Johannesburg.

The latter theory is particularly interesting and needs to be explored further. Why is resilience thinking being found in policy that was developed before the concept of resilience was considered as a design principle in the CoJ (SACN, 2011;Peyroux, 2015). There are three possible explanations, the first is that these policies which fit within the water management space are affected by the theory of 'policy by the way' (Dery, 1999; Howlett, 2019). The second is that many of the principles espoused by resilience theory are not unique to resilience theory (Xu *et al*,. 2015; Rosebaum 2016). The third reason is that policy in many cases is impacted by the individuals drafting them and the biases and theories they support.

Studies have indicated that many policies are largely made during the making of other polices, with authors employing the term 'policy by the way' to discuss this phenomenon (Dery, 1999; Howlett, 2019). 'Policy by the way' is a result of the policy making process wherein policy makers must adjust the policy they are working on based on existing policies in adjacent areas (Dery, 1999; Cejudo and Michel, 2017). For example, the *Water Conservation and Water Demand Management: Framework Strategy 2010 (WCWDM)* may have considered resilience thinking at the level that it does (a score of 82.64%), as the document may have been influenced by the *Catchment Management Policy for the City of Johannesburg 2009* and the *Integrated Environmental Management Policy 2005* amongst

other policies (JW, 2010: p. 3-10). The 'policy by the way' process could have thus guided and shaped the *WCWDM* into the document that it is, as it was impacted by policy documents from the Environment and Infrastructure Services Department, ensuring that climate change language and a focus on the environment was included within the *WCWDM.*

Climate resilience planning also incorporates principles that are not new to policy making. Adaptive governance, which is crucial component of resilience (chapter 2.2), for example, has been a component of policy development from as early as 2003 (Bowles, 2003; Ostrom, 2009). As mentioned in chapter one, sustainable development has been on the agenda in development planning since the 1970s (Ahern, 2011). Resilience and sustainable development are conceptually linked and thus the impact of sustainable development on policy has ensured that the principles of resilience planning were already being included in policy even prior to the emergence of resilience thinking in the planning discourse (Xu *et al.*, 2015; Rosebaum, 2016).

Policy in the City is also being driven by the individuals that develop the policy, thus, if the policy maker understands climate change (e.g. climate champions), resilience thinking or sustainable development will be better represented in the policies they develop (Roberts, 2016). Several studies have indicated that policy makers will promote personal agendas and biases (Gollust et al., 2017), which could result in a policy either considering climate change or omitting it completely depending on the world view of the individual developing the policy (Ampaire *et al.*, 2017).

The City of Johannesburg water management policy landscape has not been updated iteratively in conjunction with the Cities strategic documents and if they have been updated, they were not shared with the public or with this study. Sixty percent of the water management policies assessed by this study were promulgated before the *GDS 2040* was circulated. Therefore, the strategic narrative of the City as envisioned by the *GDS 2040* would hypothetically not be found in these policy documents and this was found to be the case. Looking at the language used in the documents evaluated, for example, the word 'resilience' was only used in one document that was promulgated before the *GDS 2040*, compared to it being used in both the documents assessed that were promulgated after the *GDS 2040.* Studies have found that updating the policy landscape in conjunction with updates to visionary documents like five-year and twenty-year plans, is crucial to achieving the vision and mission of those plans (Lipscomb, 2015; Heidrich *et al.*, 2016).

Policy should be updated frequently with some organisations of the opinion that the usual update cycles of between three to five years is now archaic as the world today is changing so rapidly, these organisations are of the opinion that policy should be updated yearly (Elbanna *et al.,* 2016; Fuertes *et al.,* 2020). The failure to update policy frequently can lead to organisations being left behind and failing to implement key advances in science and technology which may improve the delivery of services (Fuertes *et al.,* 2020). Thus, the impact of failing to update policy frequently will potentially have an impact on the resiliency of the CoJ, as the City may utilise archaic processes to run its operations.

The CoJ has a central and transparent data base, however this data base is not updated and there is only a fraction of the City's policies available on the data base (City Policies, 2021). The lack of well-managed central and transparent data base could undermine accountability and is potentially the reason behind the City's fractured policy ecosystem.

A central database that is well run benefits the City in many ways, for example the City will be able eliminate redundant information. The fact that the City has multiple climate change policies circulating without indicating which are redundant or obsolete makes this point particularly important (CoJ, 2009; CoJ, 2015; CoJ, 2020). This could result in CoJ officials utilising obsolete climate change policies when conducting their work. A central database also enables more effective collaboration between teams in the City and will enhance synergies between departments and break down some of the silos that exist (Forsten-Astikainen *et al.*, 2017; Oseland, 2019).

Studies indicate that when policies are developed in silos, they are seldomly implemented effectively. This is as these policies are disconnected with implementing agents and other actors including communities that are responsible for ensuring accountability from government officials (Pramova *et al.,* 2015; Ampaire *et al.,* 2017). Despite considerable progress in developing climate change adaptation policy in Africa and Latin America, studies indicate that implementation is constrained by the lack of sectoral planning and cross-functional teams (Pramova *et al.,* 2015). Studies further indicate that when a policy is widely accessible, and information is disseminated in as many ways as possible the implementation of that policy is successful (Ampaire *et al.,* 2017). The CoJ should therefore disseminate its policies as widely as possible, while ensuring that all policies that are developed are uploaded to a central database that is well managed. This will theoretically enhance policy implementation.

The City of Johannesburg water management policy landscape that was explored by this study included the principles of resilience for the most part, with two exceptions as mentioned previously. This assessment highlighted several important elements that resulted in principles of resilience being included in policy even prior to the appearance of resilience planning in the CoJ's planning discourse. This section, however, did not discuss the way the various principles of resilience were embedded in the water management policy landscape, as at a holistic level (i.e., viewing all the policies assessed collectively) they were embedded to a significant extent and would be subjected to a similar critique as the City's strategic documents (Chapter 5.1).

5.3 Practical implementation of climate change resilience in the CoJ

The City of Johannesburg's climate change education workshops seem to have created awareness for Climate Change, as confirmed by officials interviewed. City officials that did not work in the climate change space, however, were clear that climate change policy is not considered in the day-to-day work they do. When climate change benefits do arise, it is not because of a concerted effort from the City to embed climate change in policy and implementation, but because of individual knowledge. The efforts of a climate change champion can be seen in the City of Durban, where the climate champion process achieved remarkable success in implementing the climate agenda (Roberts, 2016). The CoJ should take lessons, from the City of Durban, and ensure that within each department there is a climate change champion that is capacitated, to ensure that the CoJ's climate change policies are effectively implemented.

The challenge of embedding climate change into broad policy creation and implementation is not limited to Johannesburg or the Global South but also includes first world countries (Heidrich *et al.,* 2016). Studies show that globally cities have struggled to integrate climate change adaptation and mitigation into broad policy, however this is slowly starting to change in specific geographies particularly where the impacts of climate change have been felt (Heidrich *et al.,* 2016; Aguiar *et al.,* 2018).

The CoJ should not wait for the impacts of climate change to drive change in the City but should rather ensure that it enforces the adoption of climate change mitigation and adaption in the City's policies and projects. This should be implemented in a similar manner to Municipal Finance Management Act, which has repercussions to officials. The Municipal

Finance Management Act, 2003, can result in jail time or contract termination (Government Gazette, 2014).

Johannesburg's officials interviewed considered climate change and environmental degradation to be a challenge, but socio-economic issues and infrastructure related challenges take precedence over climate change issues. Studies show that globally socio-economic challenges take precedence over environmental challenges (Chuai *et al.,* 2021), for example, in the Eastern Cape of South Africa the N2 highway is being developed to provide infrastructure to local mines despite the environmental and social impact the project will have on local communities (Ellis, 2020). The environment could become a priority, if the voters of the City considers the environment to be a priority. However, a significant proportion of this country live close or below the poverty line and survival will therefore always be the priority (CoJ, 2016a: p. 19).

While the City has several programs that have major climate change resilience benefits, officials interviewed made it clear that climate change was not the primary focus of these projects. The Bus Rapid Transport (BRT) system, for example, was implemented by the CoJ as a means to improve public transport services to previously marginalized communities and thereby reducing exclusion-related poverty (Venter, 2013). Whilst the environmental benefits of a BRT system are widely held to be substantial (Seftel and Peterson, 2014), the City chose not to highlight the significance of the climate change benefits in most of its press releases during the implementation phase of the project (Tshiunza, 2019). This could indicate the priority level of climate change in the City of Johannesburg was so low that even when there were opportunities to get environmental praise, the City did not take advantage of it. However, it should be noted that subsequent to the launch of the Reya Vaya BRT System the City has taken advantage of the positive effect of the BRT system on the environment and has published reports and articles on the climate benefits of the system (Tshiunza, 2019). This could indicate that the CoJ has made climate change a greater priority and is leveraging 'low-hanging fruit' to drive a narrative of change.

The City of Johannesburg has over the last decade developed several climate change strategies and policies (CoJ, 2009, 2015, 2020), at expense to the City. The question arises, is the development of climate change policy an exercise in futility if officials are not using these policies when developing their own policies or implementing projects (interview with officials). This is a problem that does not only impact the City of Johannesburg but is a challenge across many geographies (Wallace-Wells, 2020). The Paris Agreement, for

example, is a set of pledges and the lack of accountability on these pledges, makes measurement of progress meaningless (Kamarck, 2019). As mentioned previously, this could potentially be remedied by enforcing climate change, in a similar manner to the Municipal Finance Management Act.

The City of Johannesburg struggles with inclusive governance as public participation within the City is regularly hijacked by political parties (Interview with City official). Public participation in South Africa is regularly hijacked for political purposes, specifically to enable looting of state resources (Masiya *et al.,* 2019). Additionally, the cost of funding robust public participation is in many cases prohibitive, with departments unable to fund public participation to a satisfactory extent (Mottiar and Lodge, 2020). The impact of underfunded and a disrupted public participation process, is that public participation does not have any impact on decision-making processes (Modise, 2017). Studies indicate that when public participation is not conducted effectively, service delivery decreases and citizen participation become reactionary in the form of service delivery protests (Department of Public Service and Administration, 2014). This reduces the resilience of the CoJ, as service delivery protests in South Africa damage and destroy vital infrastructure that are required for dealing with the myriad challenges that climate change brings (Khambule *et al*., 2018).

The CoJ has several services that are duplicated by other departments within the City or by the national or provincial governments, for example, the South African Police Service and the Johannesburg Metro Police have some overlapping responsibilities. Whilst this duplication should ensure redundancy in capabilities occurs and should thus theoretically provide resilience, officials indicated that this does not take place practically. Officials interviewed indicated that redundant processes create challenges with jurisdiction by creating grey areas. It should be noted that jurisdiction challenges created by overlapping or duplicate processes is a challenge that is not limited to the CoJ only (Davies, 2009; Falkof and Van Staden, 2020).

Grey zones enable doubling-dipping from state coffers for projects and ensures that there is lack of accountability, which impacts on service delivery (Davies, 2009; Falkof and Van Staden, 2020). However, redundancy and duplicate systems do provide significant benefits and options when dealing with challenges. As mentioned previously redundancy in the American health sector promoted accountability and transparency as a result of federal and judicial reviews of policy, which allowed mistakes to be corrected through redundant mechanisms (Khan *et al.,* 2018). Whilst redundant processes provide certain benefits, as the

example illustrated, it is important that when there is redundancy in the system, these redundancies are not exploited by nefarious characters. Cross-collaboration and transparent databases can potentially improve accountability and reduce double-dipping from state coffers (Forsten-Astikainen *et al.*, 2017; Oseland, 2019).

Chapter 6: Study limits, future studies and conclusion

This aim of this study is to assess to what extent the City of Johannesburg (CoJ) embeds climate change resilience planning and relevant resilience implementation into City policy. The study also assesses the manner in which climate resilience is embedded in water management policy, as water is regarded as a fundamental link between the climate system, environment and human society. The CoJ from its strategic documents and water management policy documents could be **considered to be climate resilient**, as these documents viewed holistically or collectively indicate that the City has considered the various elements of resilience as understood by this study (Chapter 2.2 and 2.3). Climate resilience planning includes the principles of resilience, however viewed with a climate optic (Biggs *et al.,* 2015).

Whilst this study added to the climate resilience literature, several study limits should be acknowledged, (1) academic literature on climate resilience planning in South Africa is limited, however there were several non-academic studies that provided valuable information (SACN, 2011, 2014), (2) the research only considered information that was shared by the City or that was publicly available for the policy assessments, the information that was shared was not verified to determine whether this study had a complete data set of the City's policies, (3) the small sample should be noted, for both the policy assessments and the interview process, which could skew results significantly and the results presented may not be a true reflection of the state of climate resilience planning in the City of Johannesburg, and finally (4) the subjectivity and bias of the researcher (being an intern in the City and close to much of the local climate change actions and discourse) may have contributed to the outcomes of the study which could potentially lead to replicate studies finding different results compared to this study.

Notwithstanding the limitations outlined above, the results of this study do not differ markedly from the limited non-academic studies on climate resilience in the CoJ (SACN, 2011, 2014) and the academic literature on climate change planning in the CoJ (Mokwena, 2009; Hickmann and Stehle, 2019; Long and Ziervogel, 2020).

Future research should examine some of the following:

(1) is climate resilience planning a critical concept in planning discourse, as this study particularly Chapter 5.2 found that the principles of resilience planning were being utilised in the City of Johannesburg before the concept became part of the City's planning discourse as per the findings of Peyroux's study,

(2) the effect of 'policy by the way' on climate change policy and implementation, in the City of Johannesburg. Understanding the impact of 'policy by the way' could help mainstream climate change in the City of Johannesburg. 'Policy by the way' could as chapter 5.2 indicated ensure that climate change policies adjust policy making in other areas of the CoJ and finally,

(3) The CoJ's *IDPs* present numerous development plans that contribute to resilience; however the implementation of these plans needs to be evaluated. An evaluation of the CoJ's *IDPs* over a long period of time, could indicate whether the CoJ implements its plans and could provide an important view on whether the CoJ is implementing climate change or whether it is merely paying 'lip-service' to climate change.

In conclusion, the future holds significant challenges for humanity and the urban centres that host the majority of the world's populace, particularly around climate change related challenges (Biggs *et al*., 2015). The planning discourse used by cities needs to reflect these changing realities (Leichenko, 2011; Davoudi *et al.*, 2012; Harrison *et al*., 2014). While the **language of policy is important** this study showed that the **principles that underpin the various buzz words including resilience is what matters, as these principles could potentially ensure the resilience of cities in the face of climate change.**

As mentioned previously, the City of Johannesburg from its strategic documents and water management policy documents could be **considered to be climate resilient**, as these documents viewed holistically or collectively indicate that the City has considered the various elements of resilience. While **the City's consideration of resilience** ensures the City **maybe resilient to climate change**, the lack of **clear inclusion of climate change** in the implementation of many projects by officials **is a challenge** the City of Johannesburg should resolve. Workshops have proved to have been successful in the past and the CoJ should continue utilising and expanding the scope of these workshops to further mainstream climate change and resilience within the CoJ. The City should also focus on ensuring the climate change policy they do develop is adopted widely, however unless climate change policy is enforceable this could potentially be a challenge. The impact of 'Policy by the way' is

particularly interesting and the CoJ's climate change team should assess whether this process could potentially enable the mainstreaming of climate change across the City.

Our planet and people are resilient but change needs to happen before our planet reaches a point of no return. The future of policy needs to be one, where climate change is holistically included and not just a footnote. Climate Change adaptation and mitigation or climate resilience, needs to become part of performance scorecards and a requirement in project implementation and change may come in cities like Johannesburg. May this change happen soon.

Appendix 1

Table 5 Policy assessment scorecard (Harrison *et al*. 2014, Biggs *et al*. 2015, Haywood and Van der Watt 2016).

Non-compliance 0	Limited compliance 1	Partial Compliance 2	Complete compliance 3
1. Does the document show accountability toward the socio-ecological system, in terms of systems thinking?			
The document shows there is no accountability in reducing governments impact on the environment and contributing towards social responsibility.	The document shows some accountability in reducing governments impact on the environment and contributing towards social responsibility, however accountability is done in isolation and not because of systems thinking.	The document shows accountability in reducing government's impact on the environment and contributing towards social responsibility utilizing a systems approach.	The document shows accountability in reducing government's impact on the environment and contributing towards social responsibility utilizing a systems approach. In addition, the entire document embraces systems thinking.
Systems thinking assessed whether the CoJ recognized that the six capitals (Adams, 2015) from which they draw input is part of an interlinked system of people and nature and that change in one component would affect other components.			
2. Does the document recognize that government operates within a socio-ecological system that it shares with multiple users and does it recognize the impact that government has on this system?			
The document shows no recognition that government operates within a socio-ecological system and the impacts it has	The document acknowledges that government is part of a system. But social and ecological components to be	The document acknowledges that government is part of a system and incorporates social and ecological	The document acknowledges that government is part of a connected system and incorporates social and ecological components

on this system.	outside the boundaries of its planning.	components in some of its planning. It does not address the impact that government has on this system.	in all its planning. It also understands the impact that government has on this system.
Systems thinking assessed whether the CoJ recognized that the six capitals (Adams, 2015) from which they draw input is part of an interlinked system of people and nature and that change in one component would affect other components.			
3. Does the document show that government recognises major social, ecological and economic risks that the City faces?			
The document shows that governments has no recognition of risks that may affect its constituency.	The document highlights governments risk landscape to be limited to immediate risks that affect its constituency. This risk landscape does not include social and ecological risks.	The document highlights governments risk landscape to be limited to immediate risks that affect its constituency. This risk landscape includes immediate social and ecological risks.	The document highlights governments risk landscape to be inclusive of immediate and long-term risks that affect or may affect its constituency. This risk landscape includes social and ecological risks.
Immediate risks - (one-five years), long-term risks - (five-twenty years) Major risk - >ZAR 1 Billion rand impact on CoJ, Minor Risk - < ZAR 100 Million Rand impact on CoJ			
4. Does the document suggest that government plans to mitigate risk, and does it address the adaptive capacity of the socio-ecological system?			
The document shows that government has no measures in place to mitigate risk that affects its constituency.	The document indicates government has measures in place to mitigate immediate risk that affects its	The document indicates government has measures in place to mitigate immediate risk that affects its	The document indicates government has measures in place to mitigate immediate and long-term risks that affect or may affect its

	constituency. This risk does not include social and ecological risks.	constituency. This risk includes immediate social and ecological risks. However, no measures are in place to address the adaptive capacity of the system itself.	constituency. This risk includes social and ecological risks. Furthermore, government has measures in place to address the adaptive capacity of the system itself.
Immediate risks - (one-five years), long-term risks - (five-twenty years) Major risk - >ZAR 1 Billion rand impact on CoJ, Minor Risk - < ZAR 100 Million Rand impact on CoJ			
5. Does the document indicate that government consider its resource use and environmental impacts?			
The document shows that government has no measures in place to mitigate risk that affects its constituency.	The document indicates government has measures in place to mitigate immediate risk that affects its constituency. This risk does not include social and ecological risks.	The document indicates government has measures in place to mitigate immediate risk that affects its constituency. This risk includes immediate social and ecological risks. However, no measures are in place to address the adaptive capacity of the system itself.	The document indicates government has measures in place to mitigate immediate and long-term risks that affect or may affect its constituency. This risk includes social and ecological risks. Furthermore, government has measures in place to address the adaptive capacity of the system itself.
Immediate risks - (one-five years), long-term risks - (five-twenty years) Major risk - >ZAR 1 Billion rand impact on CoJ, Minor Risk - < ZAR 100 Million Rand impact on CoJ			

6. Does the document indicate that government makes investment in natural and social capital?			
The document shows that government does not invest in natural or social capital.	The document indicates government limited investment in natural and social capital.	The document indicates government invests in maintaining natural and social capital.	The document indicates government invests in maintaining and repairing natural and social capital, with a focus on building both social and natural capital with the aim of building resilience.
7. Does the document indicate that government utilises adaptive governance as envisioned by resilience planning?			
The document does not explain the governance structure and how it functions.	The document indicates that government operates in a 'top down' structure. With decisions only made at the executive level.	The document indicates that government operates as a combined 'top down' and 'bottom up' structure. However public participation is relatively limited.	The document indicates that government operates as a combined 'top down' and 'bottom up' structure. Public participation is robust and effective and does not hinder decision making.
8. Does the document indicate who are key stakeholders for government and who is responsible for decision making in government?			
The document does not indicate government considers stakeholders needs and concerns.	The document indicates that government is not responsive to the needs and concerns of stakeholders.	The document indicates that government considers stakeholders needs and concerns when making decisions. However, stakeholders do not	The document indicates that government considers stakeholders needs and concerns when making decisions. Stakeholders actively influence leadership and governance.

		actively influence leadership and governance.	
9. Does the document indicate that government considers income disparities or inequalities in its planning?			
The document shows that government has does not monitor income disparity and inequality in its constituency nor does it have plans in place to mitigate this.	The document indicates government monitors income disparity and inequality in its constituency but has no plans in place to mitigate this.	The document indicates government monitors income disparity and inequality in its constituency and has plans in place to mitigate this.	The document indicates government monitors income disparity and inequality in its constituency and is actively addressing income disparity and inequality,
10. Does the document indicate what is the planning horizon for strategy and operations?			
The document does not indicate any planning horizons for strategy and operations	The document indicates planning is primarily short-term focused. Two to five-year period of planning.	The document indicates that planning is primarily medium-term focused, which is a five to twenty-year period.	The document indicates that planning is considered at all scales including the long-term future, which is twenty years or greater.
11. Does the document indicate that government promotes learning and to what extent?			
The document does not explain how government learns.	The document indicates that government learns largely from adapting best practice from other governments or organization.	The document indicates that government encourages a culture of learning and adapts best practice from other governments or organization.	The document indicates that government encourages a culture of learning and adaption from a broad array of stakeholders including internal research. Government also maintains knowledge sharing platforms.
12. Does the document indicate that government is innovative?			

The document indicates that government stifles innovation.	The document indicates government does not promote nor does it stifle innovation	The document indicates government rewards innovation and has established a culture of innovation.	The document indicates government rewards innovation and has established a culture of innovation. Government drives innovation not only in the public sector but also in the private sector.
13. Does the document indicate that government manages its environmental slow variables and feedback loops?			
The document does not indicate that government manages its environmental slows variables and feedbacks loops	The document indicates that government is aware of its environmental slow variables and feedback loops, however, does not plan for them or around them.	The document indicates government is aware of its environmental slow variables and feedback loops and plans for them. However, government does not have any Monitoring and Evaluation processes in place.	The document indicates government is aware of its environmental slow variables and feedback loops and plans for them. Government also engages in monitoring and evaluation processes.
14. Does the document make provision for diversity and redundancy in the way it deals with various challenges that affects government?			
The document indicates that government does not have any provision for diversity and/or redundancy	The document indicates government makes some provision for diversity and redundancy, however no mention is made on organizational	The document indicates government makes provision for diversity and redundancy, however no mention is made on organizational structure.	The document indicates government makes provision for diversity and redundancy utilizing a polycentric governance template with responsibilities

	structure.		and duties clear delineated
15. Does the document indicate that government is both self-sufficient and connected?			
The document indicates that government does not have any plans to be self-sufficient and be connected	The document indicates government understands the importance of being self-sufficient and connected, however has no plans in addressing these two themes.	The document indicates government has some plans to be self-sufficient and connected	The document indicates government is self-sufficient and connected. That is government is vertically aligned with local and international governance structures and is self-sufficient in its rules and policies.

Appendix 2

Table 6 Interview schedule (Harrison *et al*. 2014, Biggs *et al*. 2015, Haywood and Van der Watt 2016)

Number	Question
1	What are the four biggest risks/challenges to the CoJ and why?
2	In your opinion what does climate change mean?
3	In terms of risks to the CoJ, where would you rank climate change?
4	What does climate change resilience mean to you?
5	Has climate change resilience been practically implemented in the city? (Can you think of an example)
6	How has the change in administration affected policies in general and climate change resilience in particular?
7	All though the city accounts for public participation in policy creation, how relevant is this and to what extent is this helpful?
8	Does the City promote learning, either formal (university/short courses) or informal (conferences/workshops)?
9	Do you think the city is innovative and does it allow its staff to be innovative?
10	The city operates as regions, can these regions operate as standalone nodes, i.e. can they survive without the support of the core administration?
11	In their redundancy and diversity in dealing with challenges, or are these challenges dealt with at specific departments only?
12	Have you used a Climate Change policy document?
13	Additional comments

Appendix 3

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Jassat

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/08/11**
PROJECT TITLE	Climate resilience planning in the City of Johannesburg
INVESTIGATOR(S)	Mr M Jassat
SCHOOL/DEPARTMENT	Animal, Plant and Environmental Sciences/
DATE CONSIDERED	16 August 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	03 November 2022

DATE 04 November 2019 **CHAIRPERSON** _____ (Professor J Knight)

cc: Supervisor : Dr U Schwaibold

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ **Signature**

_____/_____/_____ **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

References

Abbate, C., 2008. A vicious circle. *Urban climate change crossroads*: 129-134.

Abbott, J., 2009. Planning for complex metropolitan regions: a better future or a more certain one? *Journal of Planning Education and Research*, 28(4): 503-517.

Abrahams, D., 2018. Local economic development in South Africa: A useful tool for sustainable development. *Local Economic Development in the Developing World*.

Abubakar, A.M., Elrehail, H., Alatailat, M.A. and Elçi, A., 2019. Knowledge management, decision-making style and organizational performance. *Journal of Innovation & Knowledge*, 4(2):104-114.

Adams, C., 2015. Six capitals v the triple bottom line. *Integrated Reporting.*

Aguiar, F.C., Bentz, J., Silva, J.M., Fonseca, A.L., Swart, R., Santos, F.D. and Penha-Lopes, G., 2018. Adaptation to climate change at local level in Europe: An overview. *Environmental Science & Policy*, 86: 38-63.

Ahern, J., 2011. From fail-safe to safe-to-fail: Sustainable development and resilience in the new urban world. *Landscape and urban Planning*, 100(4), 341-343.

Ames, H., Glenton, C. and Lewin, S., 2019. Purposive sampling in a qualitative evidence synthesis: A worked example from a synthesis on parental perceptions of vaccination communication. *BMC medical research methodology*, *19*(1):1-9.

Ampaire, E.L., Jassogne, L., Providence, H., Acosta, M., Twyman, J., Winowiecki, L. and Van Asten, P., 2017. Institutional challenges to climate change adaptation: A case study on policy action gaps in Uganda. *Environmental Science & Policy*, 75: 81-90.

Anguelovski, I., Connolly, J. and Brand, A.L., 2018. From landscapes of utopia to the margins of the green urban life: For whom is the new green city?. *City*, 22(3): 417-436

Armitage, D., 2006. Resilience management or resilient management? A political ecology of adaptive, multi-level governance.

Bahadur, Aditya, and Tanner, T., 2014. "Transformational resilience thinking: putting people, power and politics at the heart of urban climate resilience." *Environment and Urbanization*, 26 (1): 200-214.

Bai, X., Dawson, R.J., Ürge-Vorsatz, D., Delgado, G.C., Barau, A.S., Dhakal, S., Dodman, D., Leonardsen, L., Masson-Delmotte, V., Roberts, D.C. and Schultz, S., 2018. Six research priorities for cities and climate change.

Ballew, M.T., Goldberg, M.H., Rosenthal, S.A., Gustafson, A. and Leiserowitz, A., 2019. Systems thinking as a pathway to global warming beliefs and attitudes through an ecological worldview. *Proceedings of the National Academy of Sciences*, 116(17): 8214-8219.

Bay, J.H.P. and Lehmann, S., 2017. Growing compact: Urban form, density and sustainability. *Taylor & Francis.*

Beall, J., Crankshaw, O. and Parnell, S., 2014. Uniting a divided city: Governance and social exclusion in Johannesburg. *Routledge*.

Bellinson, R., and Eric, C., 2019. Learning pathways and the governance of innovations in urban climate change resilience and adaptation. *Journal of environmental policy & planning* 21 (1): 76-89.

Bendor, J.B., 2020. 1. The Theory of Bureaucratic Competition and Redundancy. *In Parallel Systems*: 24-65

Bénit-Gbaffou, C., 2018. Beyond the policy-implementation Gap: how the city of Johannesburg manufactured the ungovernability of street trading. *The Journal of Development Studies*, 54(12): 2149-2167.

Biggs, R., Schlüter, M. and Schoon, M.L., 2015. Applying Resilience Thinking: Seven Principles for Building Resilience in Socio-ecological Systems.

Bocchini, P., Frangopol, D.M., Ummenhofer, T. and Zinke, T., 2014. Resilience and sustainable development of civil infrastructure: Toward a unified approach. *Journal of Infrastructure Systems*, 20(2).

Booyens, I., Hart, T.G. and Ramoroka, K.H., 2018. Local innovation networking dynamics: evidence from South Africa. *The European Journal of Development Research*, 30(4):749-767.

Bowles, S., 2003. Microeconomics: behavior, institutions, and evolution. *Princeton University Press.*

Braumann, E.C., Grabner, I. and Posch, A., 2020. Tone from the top in risk management: A complementarity perspective on how control systems influence risk awareness.

Bromley-Trujillo, R. and Holman, M.R., 2020. Climate change policymaking in the states: A view at 2020. *Publius: The Journal of Federalism*, 50(3): 446-472.

Brown, R.R., Keath, N. and Wong, T.H.F., 2009. Urban water management in cities: historical, current and future regimes. *Water science and technology*, 59(5), 847-855.

Brundtland Commission, 1987. World commission on environment and development. Our common future.

Bulkeley, H., 2013. Cities and climate change. *Routledge*.

Bulkeley, H. and Betsill, M.M., 2013. Revisiting the urban politics of climate change. *Environmental politics*, 22(1),.136-154.

C40. 2021. C40 Climate Action Planning Programme. Available at: https://resourcecentre.c40.org/what-we-offer#

Carlisle, K.M. and Gruby, R.L., 2018. Why the path to polycentricity matters: evidence from fisheries governance in Palau. *Environmental Policy and Governance*, 28(4): 223-235.

Cartwright, A. and Marrengane, N., 2016. Urban governance and turning African cities around: City of Johannesburg. *Partnership for African Social and Governance Research Working Paper*, 17: 756-771.

Cejudo, G.M. and Michel, C.L., 2017. Addressing fragmented government action: Coordination, coherence, and integration. *Policy Sciences*, 50(4): 745-767.

Chakraborty, A. and McMillan, A., 2015. Scenario planning for urban planners: Toward a practitioner's guide. *Journal of the American Planning Association*, *81*(1): 18-29.

Chandra, A., Acosta, J., Howard, S., Uscher-Pines, L., Williams, M., Yeung, D., Garnett, J. and Meredith, L.S., 2011. Building community resilience to disasters: A way forward to enhance national health security. *Rand health quarterly*.

Chuai, X., Lu, Q., Huang, X., Gao, R. and Zhao, R., 2021. China’s construction industry-linked economy-resources-environment flow in international trade. *Journal of Cleaner Production*

City of Johannesburg (CoJ), 2002. Sanitation Policy for the City of Johannesburg[1]

1 – The full attribution of these references are difficult to obtain from the City and most instances these policies are crafted by consultants. Thus, referencing by consultant name would hinder the search for reference material.

City of Johannesburg (CoJ), 2005. Integrated Environmental Management Policy.

City of Johannesburg (CoJ), 2009a. Climate Change Adaptation Plan.

City of Johannesburg (CoJ), 2009b. Catchment Management Policy for the City of Johannesburg 2009.

City of Johannesburg (CoJ), 2011. Growth and Development Strategy 2040.

City of Johannesburg (CoJ), 2015. Climate Change Strategic Framework City of Johannesburg.

City of Johannesburg (CoJ), 2009. Climate Change Adaptation Plan.

City of Johannesburg (CoJ), 2016a. Integrated Development Plan 2016-21.

City of Johannesburg (CoJ), 2016b. Disaster Management Strategic Action Plan 2016.

City of Johannesburg (CoJ), 2018. Integrated Development Plan 2017/18 Review.

City of Johannesburg (CoJ), 2020. 2020/21 Service Delivery Budget and Implementation Plan.

City of Johannesburg (CoJ), 2021. Climate Action Plan.

Clapp, C. and Pillay, K., 2017. Green bonds and climate finance. *Climate Finance: Theory and Practice.*

Clar, C. and Steurer, R., 2019, May. Climate change adaptation at different levels of government: Characteristics and conditions of policy change. *Natural Resources Forum,* 43 (2): 121-131

Cohen, D. and Crabtree, B., 2006. Qualitative research guidelines project.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.L., Fichefet, T., Friedlingstein, P., Gao, X., Gutowski, W.J., Johns, T., Krinner, G. and Shongwe, M., 2013. Long-term climate change: projections, commitments and irreversibility.

Committee on Climate Change, 2010. Building a low-carbon economy – the UK's innovation challenge.

Constitution, S.A. and Devenish, G.E., 1996. South African Constitution. Pretoria. *Government Printers.*

Cooke, P. and Piccaluga, A., 2006. Regional development in the knowledge economy. Routledge.

Davis, C.L. and Vincent, K., 2017. Climate risk and vulnerability: A handbook for Southern Africa.

Davoudi, S., Shaw, K., Haider, L.J., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L. and Davoudi, S., 2012. Resilience: a bridging concept or a dead end?"Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a pasture management system in Northern Afghanistan urban resilience: what does it mean in planning practice? Resilience as a useful concept for climate change adaptation? *Planning theory & practice*, 13(2): 299-333.

De Roo, G. and Juotsiniemi, A., 2010. Planning and complexity. *In Book of abstracts:24th AESOP annual conference*

de Waal, A., Weaver, M., Day, T. and van der Heijden, B., 2019. Silo-busting: Overcoming the greatest threat to organizational performance. *Sustainable development*, 11(23): 6860.

Death, C., 2014. The green economy in South Africa: Global discourses and local politics. *Politikon*, 41(1): 1-22.

Department of Environmental Affairs, 2020. National Climate Change Adaptation Strategy

Dery, D., 1999. Policy by the way. *Journal of Public Policy*, 18(2):1-14.

Desouza, K.C. and Flanery, T.H., 2013. Designing, planning, and managing resilient cities: A conceptual framework. *Cities*, 35: 89-99.

Dias-Sardinha, I. and Reijnders, L., 2005. Evaluating environmental and social performance of large Portuguese companies: a balanced scorecard approach. *Business Strategy and the Environment*, 14(2): 73-91.

Dodman, D., 2009. Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories. *Environment and urbanization*, 21(1), 185-201.

Dorling, D. and Jones, O.P., 2017. The equality effect: Improving life for everyone. *New Internationalist Publications Limited.*

du Pisanie, J., 2004. Polycentric governance as a means to limit corruption.

Dual Citizen, 2012. Global Green Economy Index

EcoMetrix Africa. 2015. Climate Change Strategic Framework. *City of Johannesburg*

Elbanna, S., Andrews, R. and Pollanen, R., 2016. Strategic planning and implementation success in public service organizations: Evidence from Canada. *Public Management Review*, 18(7): 1017-1042.

Elkin, T., McLaren, D. and Hillman, M., 1991. Reviving the city: Towards sustainable urban development. *Friends of the Earth Trust.*

Engelbrecht, F., Adegoke, J., Bopape, M.J., Naidoo, M., Garland, R., Thatcher, M., McGregor, J., Katzfey, J., Werner, M., Ichoku, C. and Gatebe, C., 2015. Projections of rapidly rising surface temperatures over Africa under low mitigation. *Environmental Research Letters*, 10(8): 085004.

Enqvist, J.P. and Ziervogel, G., 2019. Water governance and justice in Cape Town: An overview. *Wiley Interdisciplinary Reviews: Water*, 6(4).

Falkof, N. and Van Staden, C., 2020. Anxious Joburg: The inner lives of a global South city. *Wits University Press.*

Fiksel, J., 2006. Sustainable development and resilience: toward a systems approach. Sustainable development: Science. *Practice and Policy*, 2(2), 14-21.

Fiksel, J., Goodman, I. and Hecht, A., 2014. Resilience: navigating toward a sustainable future. *Solutions*, 5(5), 38-47.

Folke, C. 2006. Resilience: the emergence of a perspective for socio-ecological systems analyses. *Global Environmental Change*, 16(3), 253–267.

Forman, R.T., 2002. The missing catalyst: Design and planning with ecology roots. Ecology and design: *Frameworks for learning*, 85-109.

Forsten-Astikainen, R., Hurmelinna-Laukkanen, P., Lämsä, T., Heilmann, P. and Hyrkäs, E., 2017. Dealing with organizational silos with communities of practice and human resource management. *Journal of Workplace Learning.*

Fuertes, G., Alfaro, M., Vargas, M., Gutierrez, S., Ternero, R. and Sabattin, J., 2020. Conceptual Framework for the Strategic Management: A Literature Review—Descriptive. *Journal of Engineering*, 2020.

Gallopín, G.C., 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global environmental change*, 16(3), 293-303.

Garmestani, A. S., and Harm Benson, M. 2013. A Framework for Resilience-based Governance of Socio-ecological Systems. *U.S. Environmental Protection Agency Papers*.

Global Change Institute. 2018. Climate Change Adaptation Framework. (Draft). *City of Johannesburg*

Goldstein, B.D. and Greenberg, M.R., 2018. Global climate change and the "so what?" issue: Reversing the impact of Donald Trump.

Gollust, S.E., Seymour, J.W., Pany, M.J., Goss, A., Meisel, Z.F. and Grande, D., 2017. Mutual distrust: perspectives from researchers and policy makers on the research to policy gap in 2013 and recommendations for the future. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, 54.

Government Gazette, 2014. LOCAL GOVERNMENT: MUNICIPAL FINANCE MANAGEMENT ACT, 2003: MUNICIPAL REGULATIONS ON STANDARD CHART OF ACCOUNTS

Gunderson, L. H., & Holling, C. S. (Eds.). 2002. Panarchy: understanding transformations in human and natural systems. *Washington, D.C.: Island Press*.

Haggard, S. and Noland, M., 2009. Famine in North Korea Redux? *Journal of Asian Economics*, 20(4), 384-395.

Hamilton, J.D., 2009. Causes and Consequences of the Oil Shock of 2007-08. *National Bureau of Economic Research*.

Harper, P., 2019, *Johannesburg has a new ANC mayor — thanks to the DA - The Mail & Guardian*. Available at: https://mg.co.za/article/2019-12-04-anc-wins-johannesburg-back.

Hartley, S., McLeod, C., Clifford, M., Jewitt, S. and Ray, C., 2019. A retrospective analysis of responsible innovation for low-technology innovation in the Global South. *Journal of Responsible Innovation,* 6(2): 143-162.

Harrison, P., Bobbins, K., Culwick, C., Humby, T.L., La Mantia, C., Todes, A. and Weakley, D., 2014. Urban resilience thinking for municipalities.

Haywood, L.K. and Van der Watt, C., 2016. Building resilience into business strategy, management and reporting: Principles and maturity tool to facilitate resilience in business, 2016.

Haywood, L.K., Nahman, A., De Wet, B., Nortje, K., Van Der Watt, C. and Kelling, N.K., 2019. Principles for internalising systems resilience into business management and value creation. *Journal of Contemporary Management*, 16(2): 154-177.

Heidrich, O., Reckien, D., Olazabal, M., Foley, A., Salvia, M., de Gregorio Hurtado, S., Orru, H., Flacke, J., Geneletti, D., Pietrapertosa, F. and Hamann, J.P., 2016. National climate policies across Europe and their impacts on cities strategies. *Journal of environmental management*, 168: 36-45.

Hernantes, J., Maraña, P., Gimenez, R., Sarriegi, J.M. and Labaka, L., 2019. Towards resilient cities: A maturity model for operationalizing resilience. *Cities*, 84: 96-103.

Hetz, K., 2016. Contesting adaptation synergies: political realities in reconciling climate change adaptation with urban development in Johannesburg, South Africa. *Regional Environmental Change*, 16(4): 1171-1182.

Hickmann, T. and Stehle, F., 2017, February. Urban Climate Governance Experiments in South Africa: Insights from Johannesburg, Cape Town, and Durban. *ISA Annual Convention held in Baltimore*

Hickmann, T. and Stehle, F., 2019. The embeddedness of urban climate politics in multilevel governance: A case study of South Africa's major cities. The Journal of Environment & Development, 28(1), pp.54-77.

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bolaños, T.G., Bindi, M., Brown, S., Camilloni, I.A., Diedhiou, A., Djalante, R., Ebi, K. and Engelbrecht, F., 2019. The human imperative of stabilizing global climate change at 1.5 C. *Science*, 365(6459).

Holling, C.S., 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics*, 4(1): 1-23.

Hoornweg, D., Freire, M., Lee, M.J., Bhada-Tata, P. and Yuen, B., 2011. Cities and climate change: responding to an urgent agenda. *The World Bank*.

Howlett, M., 2019. Designing public policies: Principles and instruments. *Routledge.*

Hudson, R., 2010. Resilient regions in an uncertain world: wishful thinking or a practical reality?. *Cambridge Journal of Regions, Economy and Society*, 3(1):11-25.

Hunt, A. and Watkiss, P., 2011. Climate change impacts and adaptation in cities: a review of the literature. *Climatic change*, 104(1), 13-49.

Ims, R.A. and Yoccoz, N.G., 2017. Ecosystem-based monitoring in the age of rapid climate change and new technologies. *Current Opinion in Environmental Sustainability*, *29*:170-176.

INTEGRATED DEVELOPMENT PLANNING FOR LOCAL GOVERNMENT (IDPLG). 2018. Available at: http://www.etu.org.za/toolbox/docs/localgov/webidp.html

IPCC. 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

IPCC. 2008. Climate change and water.

Islam, N. and Winkel, J., 2017. Climate change and social inequality.

Iversen, G.R. and Gudmund, I.R., 1991. Contextual analysis. *Sage*.

Jabareen, Y., 2013. Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities*, 31: 220-229.

Jeuland, M.A. and Pattanayak, S.K., 2012. Benefits and costs of improved cookstoves: assessing the implications of variability in health, forest and climate impacts. *PloS one*, 7(2)

Johannesburg Road Agency (JRA), 2017. Strategy 2017

Johannesburg Water (JW), 2010. Water Conservation and Water Demand Management: Framework Strategy 2010

Johannesburg Water (JW), 2020. About us. Available at: https://johannesburgwater.co.za/about-us/

Kaika, M., 2017. 'Don't call me resilient again!': The New Urban Agenda as immunology… or… what happens when communities refuse to be vaccinated with 'smart cities' and indicators. *Environment and Urbanization*, 29(1): 89-102.

Kamarck, E., 2019. *The challenging politics of climate change*. Available at: https://www.brookings.edu/research/the-challenging-politics-of-climate-change.

Kareem, B., Lwasa, S., Tugume, D., Mukwaya, P., Walubwa, J., Owuor, S., Kasaija, P., Sseviiri, H., Nsangi, G. and Byarugaba, D., 2020. Pathways for resilience to climate change in African cities. *Environmental Research Letters*, 15(7)

Khambule, I., Nomdo, A. and Siswana, B., 2018. The social cost of violent and destructive service-delivery protests in South Africa. *Human Sciences Research Council (HSRC) Review*, 16(4): 26-27.

Khan, Y., O'Sullivan, T., Brown, A., Tracey, S., Gibson, J., Généreux, M., Henry, B. and Schwartz, B., 2018. Public health emergency preparedness: a framework to promote resilience. *BMC public health*, 18(1):1-16.

Klopp, J.M., Harber, J. and Quarshie, M., 2019. A review of BRT as public transport reform in African cities. *VREF Research Synthesis Project Governance of Metropolitan Transport*.

Leichenko, R., 2011. Climate change and urban resilience. Current opinion in environmental sustainable development, 3(3): 164-168.

Lewis, J., 2017. Social impacts of corruption upon community resilience and poverty. *Jàmbá: Journal of Disaster Risk Studies*, 9(1): 1-8.

Lewis, J.M., Ricard, L.M. and Klijn, E.H., 2018. How innovation drivers, networking and leadership shape public sector innovation capacity. *International Review of Administrative Sciences*, 84(2): 288-307.

Lipscomb, P., 2015. Updating Our Bylaws. *Law Library Lights*

Lodge, T., 2020. Election 2019: Change and stability in South Africa's democracy:

Long, D. and Ziervogel, G., 2020. Vulnerability and adaptation to climate change in urban South Africa. *Urban Geography in South Africa*, 139-153.

MacKillop, F., 2012. Climatic city: Two centuries of urban planning and climate science in Manchester (UK) and its region. *Cities*, 29(4), 244-251.

Mann, M.E., Rahmstorf, S., Kornhuber, K., Steinman, B.A., Miller, S.K. and Coumou, D., 2017. Influence of anthropogenic climate change on planetary wave resonance and extreme weather events. *Scientific Reports*, 7, 452.

Marchese, D., Reynolds, E., Bates, M.E., Morgan, H., Clark, S.S. and Linkov, I., 2018. Resilience and sustainable development: Similarities and differences in environmental management applications. *Science of the total environment*, 613: 1275-1283.

Masiya, T., Davids, Y.D. and Mangai, M.S., 2019. Assessing service delivery: Public perception of municipal service delivery in South Africa.

Matikinca, P., Ziervogel, G. and Enqvist, J.P., 2020. Drought response impacts on household water use practices in Cape Town, South Africa. Water Policy, 22(3), pp.483-500.

McGranahan, G., Balk, D. and Anderson, B., 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and urbanization*, 19(1), 17-37.

Meijer, M., Adriaens, F., van der Linden, O. and Schik, W., 2011. A next step for sustainable urban design in the Netherlands. *Cities*, 28(6), 536-544.

Mikkelson, G.M., Gonzalez, A. and Peterson, G.D., 2007. Economic inequality predicts biodiversity loss. *PloS one*, 2(5)

Mirfenderesk, H. and Corkill, D., 2009. The need for adaptive strategic planning: Sustainable management of risks associated with climate change. *International Journal of Climate Change Strategies and Management*, 1(2), 146-159.

Modise, L.J., 2017. The notion of participatory democracy in relation to local ward committees: The distribution of power. *In die Skriflig*, 51(1): 1-8.

Mokwena, L., 2009. Municipal responses to climate change in South Africa: the case of eThekwini, the City of Cape Town, and the City of Johannesburg.

Monstadt, J. and Schmidt, M., 2019. Urban resilience in the making? The governance of critical infrastructures in German cities. *Urban Studies*, 56(11): 2353-2371.

Morecroft, M.D., Crick, H.Q., Duffield, S.J. and Macgregor, N.A. 2012. Resilience to climate change: translating principles into practice. *Journal of Applied Ecology*

Mottiar, S. and Lodge, T., 2020. 'Living inside the movement': The Right2Know campaign, South Africa. *Transformation: Critical Perspectives on Southern Africa*, 102(1): 95-120.

Mulgan, R. 2002. Accountability Issues in the New Model of Governance. *Discussion Paper No. 91*, available online at http://firgoa.usc.es/drupal/files/No91Mulgan.pdf

Muller, M., 2007. Adapting to climate change: water management for urban resilience. *Environment and Urbanization*, 19(1), 99-113.

Muller, M., 2012. Polycentric governance: water management in South Africa. *Proceedings of the Institution of Civil Engineers-Management, Procurement and Law*, 165(3): 193-200.

Muller, M., 2017. Understanding the origins of Cape Town's water crisis. *Civil Engineering Siviele Ingenieurswese*, 2017(5), 11-16.

National Planning Commission, 2012. National Development Plan 2030: Our future–make it work. *Pretoria: Presidency of South Africa*.

Nelson, A.C. and French, S.P., 2002. Plan quality and mitigating damage from natural disasters: A case study of the Northridge earthquake with planning policy considerations. *Journal of the American Planning Association*, 68(2),194-207.

Newman, P., 2006. The environmental impact of cities. *Environment and Urbanization*, 18(2), 275-295.

Njinga, R.L. and Tshivhase, V.M., 2017. The impact of mine tailings on the Witwatersrand and the surrounding water bodies in Gauteng Province, South Africa. *Mine Water and the Environment*, 36(4): 638-645.

Nowell, B., Bodkin, C.P. and Bayoumi, D., 2017. Redundancy as a strategy in disaster response systems: A pathway to resilience or a recipe for disaster?. *Journal of Contingencies and Crisis Management*, 25(3): 123-135.

Nyenhuis, R. and Krönke, M., 2019. The 2019 South African elections-incumbency and uncertainty. *Journal of African Elections*, 18(2): 112-133.

Nygren, B., Aléx, L., Jonsén, E., Gustafson, Y., Norberg, A. and Lundman, B., 2005. Resilience, sense of coherence, purpose in life and self-transcendence in relation to perceived physical and mental health among the oldest old. *Aging & mental health*, 9(4),354-362.

OECD. 2013. Water and climate change adaptation: Policies to navigate uncharted waters. *OECD publishing*

Ojerio, R., Moseley, C., Lynn, K. and Bania, N., 2010. Limited involvement of socially vulnerable populations in federal programs to mitigate wildfire risk in Arizona. *Natural Hazards Review*, 12(1), 28-36.

Oseland, S.E., 2019. Breaking silos: can cities break down institutional barriers in climate planning?. *Journal of Environmental Policy & Planning*, 21(4): 345-357.

Ostrom, V., Tiebout, C.M. and Warren, R., 1961. The organization of government in metropolitan areas: a theoretical inquiry. *The American political science review*, 55(4): 831-842.

Ostrom, E., 2009. Understanding institutional diversity. *Princeton university press.*

Ostrom, E., 2010. Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), 550-557.

Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19(3): 354-365.

Paret, M., 2018. Beyond post-apartheid politics? Cleavages, protest and elections in South Africa. *The Journal of Modern African Studies*, 56(3): 471-496.

Pellegrino, G. and Savona, M., 2017. No money, no honey? Financial versus knowledge and demand constraints on innovation. *Research Policy*, 46(2): 510-521.

Perine, C. and Keuck, H., 2018. BUILDING URBAN RESILIENCE TO CLIMATE CHANGE: A REVIEW OF SOUTH AFRICA. *USAID.*

Peyroux, E., 2015. Discourse of urban resilience and 'inclusive development'in the Johannesburg Growth and Development Strategy 2040. *The European Journal of Development Research*, 27(4): 560-573.

Pikitupco, 2019. Contact. Available at: http://www.pikitup.co.za/contact-us/

Plummer, R., 2012, March. Fostering governance and building capacity for climate change adaptation: can adaptive co-management help.

Pojani, D. and Stead, D., 2018. Policy design for sustainable urban transport in the global south. *Policy Design and Practice*, 1(2): 90-102.

Pramova, E., Di Gregorio, M. and Locatelli, B., 2015. Integrating adaptation and mitigation in climate change and land-use policies in Peru. *CIFOR.*

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. *Biological conservation*, 141(10), 2417-2431.

Resilience Alliance. 2010. Assessing resilience in socio-ecological systems: workbook for practitioners.

Roberts, D., 2010. Prioritizing climate change adaptation and local level resilience in Durban, South Africa. *Environment and Urbanization*, 22(2): 397-413.

Roberts, D. and O'Donoghue, S., 2013. Urban environmental challenges and climate change action in Durban, South Africa. *Environment and Urbanization*, 25(2): 299-319.

Roberts, D., 2016. The new climate calculus: 1.5 C= Paris Agreement, cities, local government, science and champions (PLSC2). Urbanisation, 1(2): 71-78.

Rockefeller Foundation & ARUP. 2014. City Resilience Framework. Available at http://www.rockefellerfoundation.org/uploads/files/0bb537c0-d872-467f-9470-b20f57c32488.pd

Rodina, L., 2019. Water resilience lessons from Cape Town's water crisis. *Wiley Interdisciplinary Reviews: Water*, 6(6)

Rogerson, C.M. and Rogerson, J.M., 2016. Intra-urban spatial differentiation of tourism: Evidence from Johannesburg, South Africa. *Urbani izziv*, 27(2): 125-137.

Rogerson, C.M., 2018. Towards pro-poor local economic development: the case for sectoral targeting in South Africa. In *Local Economic Development in the Changing World*, 75-100.

Romero Lankao, P., 2007. How do local governments in Mexico City manage global warming? *Local Environment*, 12(5), 519-535.

Romero-Lankao, P., McPhearson, T. and Davidson, D.J., 2017. The food-energy-water nexus and urban complexity. *Nature Climate Change*, 7(4): 233-235.

Rosenbaum, W.A., 2016. Environmental politics and policy. *CQ press.*

Roy, A., 2016. Informality and the politics of planning. In *The Ashgate Research Companion to Planning Theory*.

Satterthwaite, D., 2008, January. Climate change and urbanization: Effects and implications for urban governance. *In United Nations Expert Group meeting on population distribution, urbanization, internal migration and development*. 21-23. DESA New York.

Seftel, L. and Peterson, B., 2014. Achieving sustainable development in BRT implementation in the City of Johannesburg

Schmidt, D., 2008. From spheres to tiers–conceptions of local government in South Africa in the period 1994–2006. *Consolidating developmental local government: lessons from the South African experience*, 109-130.

Scholte, J.A., 2004. Globalization and governance: from statism to polycentrism. *University of Warwick Centre for the Study of Globalisation and Regionalisation.*

Scott, D., Hall, C.M. and Gössling, S., 2019. Global tourism vulnerability to climate change. *Annals of Tourism Research*, 77: 49-61.

Simpson, NP, Shearing, CD and Dupont, B., 2020, '"Partial functional redundancy": An expression of household level resilience in response to climate risk', *Climate Risk Management*

Skoufias, E., 2012. The poverty and welfare impacts of climate change: quantifying the effects, identifying the adaptation strategies. *World Bank Publications.*

South Africa., 1993. Local Government Transition Act, 1993.

South African Cities Network (SACN), 2011. Towards Resilient Cities

South African Cities Network (SACN), 2014. Context of Climate Change Resilience at Local Government Level

Statistics South Africa, 2015. Local Municipality | Statistics South Africa, Statssa.gov.za. Available at: http://www.statssa.gov.za/?page_id=993&id=city-of-johannesburg-municipality

Stone, F., 2004. Deconstructing silos and supporting collaboration. *Employment Relations Today*, 31(1), p.11.

Streeter, C.L., 1992. Redundancy in organizational systems. *Social Service Review*, 66(1): 97-111.

Taşan-Kok, T., Stead, D. and Lu, P., 2013. Conceptual overview of resilience: History and context. *Resilience thinking in urban planning*.

Thebe, T.P., 2016. Community participation: reality and rhetoric in the development and implementation of the Integrated Development Plan (IDP) within municipalities of South Africa.Journal of Public Administration

Theeboom, E., Johnston, P., Braune, M., Hewitson, B., Coop, L., 2009. Climate Change Adaptation Plan. *City of Johannesburg*.

Timmerman, P., 1981. Vulnerability resilience and collapse of society. A Review of Models and Possible Climatic Applications. *Institute for Environmental Studies, University of Toronto.*

Todes, A., Karam, A., Klug, N. and Malaza, N., 2010. Beyond master planning? New approaches to spatial planning in Ekurhuleni, South Africa. *Habitat International*, 34(4), 414-420.

Tshiunza, R., 2019. Environmental compliance and sustainable development in South Africa: a study of the transport industry in Johannesburg.

Turok, I., 1991. Policy evaluation as science: a critical assessment. *Applied Economics*, 23(9): 1543-1550.

Turton, A., Schultz, C., Buckle, H., Kgomongoe, M., Malungani, T. and Drackner, M., 2006. Gold, scorched earth and water: the hydropolitics of Johannesburg. *Water Resources Development*, 22(2): 313-335.

Tyler, S. and Moench, M., 2012. A framework for urban climate resilience. *Climate and development*, 4(4), 311-326.

UNISDR, 2012. Making cities resilient: my city is getting ready. *United Nations International Strategy for Disaster Reduction*.

United Nations Environment Programme (UNEP), 2011. ANNUAL REPORT 2011

UN-Water 2018. Climate change. Available at: http://www.unwater.org/water-facts/climate-change

Venter, C., 2013. The lurch towards formalisation: Lessons from the implementation of BRT in Johannesburg, South Africa. *Research in Transportation Economics*, 39(1): 114-120.

Vogel, C., Mukute, M., Coetzer, K. and Gwata, M., 2021. Creating a climate of change in the City of Johannesburg: Co-learning to adapt to climate change. *South African Journal of Science*, 117(9/10).

Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R. and Davies, P.M., 2010. Global threats to human water security and river biodiversity. *Nature*, 467(7315), 555.

Walker, B., & Salt, D. 2006. Resilience thinking: sustaining ecosystems and people in a changing world. *Washington DC: Island Press.*

Wallace-Wells, D., 2020. The uninhabitable earth: Life after warming. *Tim Duggan Books.*

Wardekker, J.A., de Jong, A., Knoop, J.M. and van der Sluijs, J.P., 2010. Operationalising a resilience approach to adapting an urban delta to uncertain climate changes. *Technological Forecasting and Social Change*, 77(6),987-998.

Weit, C., Chetcuti, S., Wei, L., Muehlberg, M., Chan, C., Gilani, H., Clanchy, C., Schwartz, K.N., Sudol, A., Tai, J.C. and Bil, C., 2018. Modeling Airlift Operations for Humanitarian Aid and Disaster Relief to Support Acquisition Decision-Making. *In 2018 Aviation Technology, Integration, and Operations Conference.*

West, J.M., Julius, S.H., Kareiva, P., Enquist, C., Lawler, J.J., Petersen, B., Johnson, A.E. and Shaw, M.R., 2009. US natural resources and climate change: concepts and approaches for management adaptation. *Environmental management*, 44(6), 1001.

Wheeler, S.M., 2002. Constructing sustainable development/safeguarding our common future: Rethinking sustainable development. *Journal of the American Planning Association*, 68(1), 110.

Wiedmann, T.O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J. and Kanemoto, K., 2015. The material footprint of nations. Proceedings of the national academy of sciences, 112(20): 6271-6276.

Winkler, T., 2013, September. Why won't downtown Johannesburg 'regenerate'? Reassessing Hillbrow as a case example. *In Urban Forum* 24 (3): 309-324.

Wolf, T.L., 2018. Urban Water Security and Water Management. A Case of the Johannesburg Metropolitan Area

Woodruff, S.C., Meerow, S., Stults, M. and Wilkins, C., 2018. Adaptation to resilience planning: Alternative pathways to prepare for climate change. *Journal of Planning Education and Research.*

Xu, L., Marinova, D. and Guo, X., 2015. Resilience thinking: a renewed system approach for sustainable development science. *Sustainable development Science*, 10(1): 123-138.

Yu, Y., Zhou, L., Zhou, W., Ren, H., Kharrazi, A., Ma, T. and Zhu, B., 2017. Decoupling environmental pressure from economic growth on city level: The Case Study of Chongqing in China. *Ecological Indicators,* 75: 27-35.

Zadeh-Cummings, N. and Harris, L., 2020. The Impact of Sanctions against North Korea on Humanitarian Aid. *Journal of Humanitarian Affairs,* 2(1): 44-52.

Zevenbergen, C., Khan, S.A., van Alphen, J., Terwisscha van Scheltinga, C. and Veerbeek, W., 2018. Adaptive delta management: a comparison between the Netherlands and Bangladesh Delta program. *International Journal of River Basin Management*, 16(3): 299-305.

Zhang, Y., 2010. Residential housing choice in a multihazard environment: Implications for natural hazards mitigation and community environmental justice. *Journal of Planning Education and Research,* 30(2), 117-131.