TOWARDS AN INTEGRATED AND SUSTAINABLE WATER RESOURCE MONITORING FRAMEWORK IN SOUTH AFRICA

BY

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DECLARATION

I, Simphiwe Chabalala, declare that this thesis, including data, tables, diagrams, graphs and any other information, is my own unaided work.

The thesis is being submitted for the Degree of Doctor of Philosophy to the Faculty of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any examination to any other University.

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ABSTRACT

Water resource monitoring plays a pivotal role in a number of sectors such as determining sustainable abstraction and use of water, determining the feasibility of development projects in relation to water, and developing systematic strategies for efficient overall management of the water resources. It has been observed by a number of scholars and policy makers that through periodic monitoring of water resources, valuable data can be collected which can then provide information sufficient to determine trends and develop predictive models. It is only when sound and reliable data is available that informed decisions about sustainable and efficient use of water resources can be made. Despite the importance of water resource monitoring, many countries in Sub-Saharan Africa, particularly in South Africa, are not effectively and adequately monitoring the quantity and quality of water resources. Part of the reason for this state of affairs has been the absence of clearly defined roles, policies, strategies and responsibilities and a combination of these factors have resulted in significant fragmentations in the institutional structures mandated to manage water resources. Using expert sampling, interviews with key informants and other purposively chosen participants, revealed the challenges in the changing political landscape of South African water resource monitoring many of which were further reiterated in the focus group discussions. The identified challenges served as entry points that would improve water resources monitoring and enable decision makers to make sustainable management decisions. It is suggested that water resource monitoring programmes could be used as a tool for sustainable water resource monitoring in South Africa. However, climate change and urbanization bring about a certain level of complexity, uncertainty and conflict as the water landscape of water resources changes continuously. The impact of the above phenomena cannot be measured as current monitoring systems are not functioning optimally. Furthermore, monitoring programmes are not being used to their full potential due to governance challenges. This is due to conflicting roles that the Department of Water

and Sanitation (DWS) plays in the water sector i.e. policy developer, supporter and regulator, which in turn confound the roles and responsibilities of its employees. Moreover, it was found that five major challenges impede the formation of a comprehensive water resources management system namely; lack of financial resources, lack of skilled human resources, poor governance structure, ineffective stakeholder engagement – 'working in silos' and inefficient data management. More importantly, it was found that sustainability of monitoring programmes relies on human and economic investment. The main recommendations made include institutional reform and enabling legislation which form the basis upon which any development efforts can be pursued to achieve sustainable water resource monitoring. In addition, capacity building and strengthening is recommended as another way to help build sustainable resource management institutions which include skills and institutional memory transfer from the experienced players to the younger and newer employees. The creation and/or optimization of water resource monitoring databases is one of the viable ways for sustainable water resource management to be realized. Furthermore, research can be conducted to assess the challenges in water resource monitoring and provide sustainable solutions; with the aim of quantifying the impact of policy reforms in the water sector. And finally, research can be done on how effective regulation and co-operative governance for water sector can be achieved in South Africa through participatory processes that are aimed at developing priority water research questions.

Keywords: water resource monitoring, institutional framework, integrated water resource management, water governance.

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LIST OF ABBREVIATIONS AND ACRONYMS

AMCOW	African Ministers' Council on Water
AMD	Acid Mine Drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CBO	Community Based Organizations
CESD	Commissioner of the Environment Sustainable Development
CMA	Catchment Management Agencies
CP	Collaborative Planning
CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EUWI-FWG	European Union Water Initiative - Finance Working Group
GDARD	Gauteng Department of Agriculture and Rural Development
GWP	Global Water Partnership
HR	Human Resources

INRM	Integrated Natural Resource Management
IP	Information Programmes
IRR	Institutional Reform and Re-alignment
IRWMC	Integrated Regional Water Monitoring Committee
ISO	International Organization for Standardization
IWRM	Integrated Water Resource Management
IWRM	Integrated Water Resource Management
MDGs	Millennium Development Goals
MTT	Monitoring Task Team
NDP	National Development Plan
NGO	Non Governmental Organization
NHP	National Hydrometric Programme
NIWIS	National Integrated Water Information System
NWA	National Water Act
NWMC	National Water Monitoring Committee
NWMP	National Water Monitoring Programme
NWP	National Water Policy
NWQMS	National Water Quality Management Strategy
NWRS1and2	National Water Resource Strategy1and2
NWSSCO	National Water Supply and Sanitation Council

OECD	Organization for Economic Co-operation and Development
OSD	Occupation Specific Dispensation
RHP	River Health Monitoring Programme
RQIS	Resource Quality Information Service
SADC	Southern Africa Development Community
SAICE	South African Institute for Civil Engineering
SANBI	South African National Botanical Institute
SASS	South African Scoring System
SCM	Supply Chain Management
SDGs	Sustainable Development Goals
SOE	State Owned Enterprises
SSA	Sub-Saharan Africa
StatsSA	Statistics South Africa
TERI	The Energy and Resources Institute
UN	United Nations
UNDP	United Nations Development Programme
UNISA	University of South Africa
USA	United States of America
WCED	World Commission on Environment and Development

WGDF	Water for Growth and Development in South Africa Framework
WMA	Water Management Area
WRC	Water Research Commission
WRFMC	Water Resource Functional Management Committee
WSP	Water Service Provider
WSSD	World Summit on Sustainable Development
WUA	Water Users' Association
WWTW	Waste Water Treatment Works

CHAPTER ONE

FRAMES OF REFERENCE

1.1 INTRODUCTION

The magnitude of the global water crisis and the risks associated with it has been severely underestimated, hence the urgency to address the growing number of risks associated with threatened water supply and quality. This in turn triggers the need for a change in policies, institutions and the manner in which society perceives water. It is argued for example that 14 per cent of the earth's population is without a dependable supply of safe water while more than 29 per cent lack basic sanitation (Bigas, 2012). Sustainable Development Goals (SDGs) constitute an important opportunity to move beyond the development agenda of the Millennium Development Goals (MDGs) towards a universally relevant agenda that integrates social, economic and environmental goals, and includes targets for both developed and developing countries (Hajer *et al*., 2015). Sustainable Development Goals (SDGs) are a United Nations initiative that aims to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda where each goal has specific targets to be achieved over the next 15 years. One of the goals is to ensure access to clean water and sanitation for all, which is SDGs goal number 6 (UN, 2015).

Some of the SDGs targets set out include; universal and equitable access to safe and affordable drinking water for all; improving water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse of water globally, substantially increasing water-use efficiency across all sectors and ensuring sustainable withdrawals and supply of freshwater to address water scarcity and substantially reducing the number of people suffering

from water scarcity, implementing integrated water resources management at all levels, including trans-boundary cooperation as appropriate, protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes by 2030 (UN, 2015). To date, more than 2.6 billion people have gained access to improved drinking water sources since 1990. Between 1990 and 2015, the proportion of the global population using an improved drinking water source has increased from 76 per cent to 91 per cent, however; 662 million people are still without water, while 2.4 billion people lack access to basic sanitation services, such as toilets or latrines (SDG Report, 2013).

To complicate matters further, water stress is expanding globally but especially for mid-latitude countries that are already deemed to be water scarce, threatening to further undermine important development progress (Bigas, 2012). Moreover, to ensure that the SDGs framework will be more than the (much needed) extension of the current MDGs agenda to 2030, the environmental preconditions for human development need to be recognized in goals and targets (Griggs et al., 2013). However, environmental sustainability is inconsistently covered in the framework of SDGs goals that have emerged from political negotiations so far. Environmental concerns are less often named in goals, less well-defined and more often addressed in targets under goals focussed on the social and economic dimensions of sustainable development (Raworth, 2014). For example, the proposed targets for halting biodiversity loss and combating climate change do not have target dates. For other environmental concerns it remains unclear when a target would be considered as achieved. With its focus on the environmental preconditions for sustainable development, the planetary boundaries perspective can strengthen the focus on environmental concerns (Hajer et al., 2015).

South Africa is committed to international declarations on sustainable water services development, including the “Earth Summit” in Rio (1992), the UN General Assembly resolution on MDGs (Millennium Development

Goals) (2000), the World Summit on Sustainable Development in Johannesburg (2002) and the UN General Assembly resolutions on Sustainable Development Goals (SDGs) (2015). The water services related to SDGs were to halve the proportion of people not having sustainable access to safe drinking water by 2015 using 1994 as a base year and to halve the proportion of people without sustainable access to a basic sanitation service using 1994 as a base year. Both were achieved in 2005 and 2008 respectively but there is still a long way to go (DWA, 2013). In view of the limited success of environmental governance, the SDGs need target not only governments, but other agents of change such as businesses, cities, citizens and civil society (Hajer et al., 2015).

South Africa is classified as a water-stressed country, with an average annual rainfall of around 500 millimetres, which is less than 60 per cent of the world average (Mukheibir, 2007). In addition, South Africa's growing water demand is rapidly outstripping its natural availability with a population of 51.77 million people. The country is made up of nine provinces; Gauteng is the most densely populated (12.3 million people) and the Northern Cape the least populated (with just over a million people). South Africa is categorized as the 30th driest country in the world (DWA, 2013). The country is semi-arid with rainfall varying from less than 100 millimetres per annum in the west to over 1500 millimetres per annum in the east. Climate change predictions are for a drier western half of the country and for far more variability, with more extreme events, to the east. It is also a water scarce country with extreme climate and rainfall fluctuations. South Africa's water usage typically comprises of 77 per cent surface water, nine percent groundwater, and 14 per cent re-use of return flows (DWA, 2013). In the Northern Cape for example, many local municipalities resorted to providing water by road tankers to communities whose groundwater supplies had been reduced due to drought conditions (Mukheibir, 2007).

1.2 RESEARCH STATEMENT

A well-proven management principle states that; “If you cannot measure it, you cannot manage it” (Deming, 1986). This principle applies as much to water resource management as it applies to managing any other kind of human endeavour. This principle is recognized explicitly in Chapter 14 of the National Water Act (NWA, Act No. 36 of 1998) (DWAF, 1998) that requires monitoring of water resources quality to be an integral part of water resources management in South Africa. The NWA mandates the Minister of Water Affairs and Forestry to establish national monitoring systems that monitor, record, assess and disseminate information regarding, amongst many other things, the quality of water resources to equip decision makers with knowledge needed to make water management decisions. Water quantity data and information is used to determine how much water is available for various uses such as irrigation, industrial and domestic uses, to make trans-boundary water allocation decisions, and for flood forecasting.

Most regions are not adequately monitoring the quality and quantity of South Africa’s surface water resources. Although there are 11 existing water resource quality monitoring programmes in the Department of Water and Sanitation (DWS), the department has not fully defined the extent of its water monitoring responsibilities. It is not clear to some local authorities whose responsibility it is to monitor water resource quality - national parks, provincial government, national government, water services authorities or providers, or the water catchment management authorities? The Department of Water and Sanitation (DWS) is not adequately monitoring water quality on the majority of entities at this level and does not know whether other environmental institutions are doing so. As a result, there are vast areas under national and/or regional jurisdiction where fresh water quality and quantity conditions are not being monitored.

The DWS has not established many of the vital management structures needed to plan, implement, assess, and improve its long-term monitoring programmes. It has not taken the preliminary steps to clearly establish the extent of each programme's monitoring responsibilities, risk-based priorities, and client needs. As a consequence, the DWS has no objective basis on which to identify opportunities for improvement or take corrective actions to improve these programmes. In view of the above observations, there is a need to audit the developed quality control procedures of monitoring programmes to ensure that data collected and disseminated is fit for intended use. As it stands, DWS cannot completely assure users that the water quality data is fit for intended users as data is stored in many different places and ends being lost due to a number of different reasons like retiring professionals, under-qualified staff and high staff turnover.

Despite the current institutional setup in the water resource management and delivery of potable water in South Africa, there seems to be fragmentation of roles and responsibilities in water resource monitoring. Currently, there are no guidelines or structures that define the roles and responsibilities in water resource monitoring and this has resulted in a conflict of interest between Water Service Providers (WSPs) and the Department of Water and Sanitation. **In view of this understanding this study was interested in investigating the factors that make it difficult to develop a framework through which effective water resource management can be pursued in order to promote sustainable water resource monitoring and development in South Africa.**

1.3 RATIONALE

South African government welcomed the concept of Integrated Water Resource Management (IWRM) in 1994 and international experience in water resource management, where the concept of water as a social good and emphasis on the implications of equity for the pillar of water as an

economic good was clearly outlined. South Africa then received global acclaim for catchment management agencies, public trust doctrine and the ecological reserve that gave the IWRM community hope that it could work. After two decades of trial and error, equity has been increasingly firmly entrenched in South Africa's water policies. In 2013, the DWS issued the National Water Resource Strategy 2 (NWRS2) that introduced the concept of developmental water management which reflects and builds on the IWRM principles of equity, environmental sustainability and efficiency and underpin the National Water Policy and National Water Act.

Despite South Africa having impressive policies; evidence for the success of IWRM is mixed and has come under criticism recently as failing to provide promised benefits in terms of implementation (Kgomotso, 2005). Investigating the role of the institutional framework within South Africa in water resource monitoring, will assist in the attempt to understand the institutional framework regarding water resource management that hinders effective IWRM. Existing literature on water resource monitoring indicates that the South African research focus is on issues of water quality and quantity. What it fails to do is to discuss and address the weaknesses of water monitoring governance in a new democracy such as South Africa. In view of the above, this study sought to understand the relationships between (i) Institutional fragmentation approach in the current regulatory environment **and** ineffective and unsustainable water monitoring programmes, (ii) The role of DWS as policy developer, supporter and regulator (referee and player) in the monitoring system **and** failure of the water monitoring sector to comply and enforce regulation on water resources, (iii) The lack of capacity in DWS for monitoring purposes **and** the participants' understanding of their role in the water resource monitoring value chain (IRR, 2008).

1.4 RESEARCH QUESTIONS

In view of the research focus stated above, the following questions guided the research process;

I. To what extent can water monitoring programmes be used as a tool for sustainable management of water resources in South Africa and what effect does climate change, water scarcity, increased water use and urbanization have on the country's water resources?
II. What institutional framework exists within which effective water monitoring programmes can be pursued in South Africa?
III. What factors can play a role in institutional fragmentation that impedes the formation of a comprehensive management system of water resources monitoring?
IV. What are the implications of the findings of this study in a wider context, for other regions in South Africa and developing countries?

1.5 AIM AND OBJECTIVES

The current water resource monitoring management system has no clearly defined roles and responsibilities which results in the fragmentation of institutional structure; therefore the aim was to investigate factors that account for the non-existence of an effective and unified water resource monitoring system in South Africa. The objectives of the study were as follows;

I. Create an inventory of current challenges in water resource monitoring system in South Africa,
II. Identify entry points towards formulating an effective water resource monitoring management system,

III. Identify and review factors accounting for the non-existence of water resource monitoring management systems in South Africa.

1.6 THEORETICAL PERSPECTIVES

The purpose of water resource monitoring is generally laid down by laws or other regulatory actions (directives, water quality standards, action plans) and aims at assessing the environmental state and detecting trends (Macatsha, 2006). It involves the programmed process of sampling, measurement and subsequent recording or signalling or both of various water characteristics, often with the aim of assessing conformity to specified objectives. One can also define monitoring as the effort to obtain quantitative information on the physical, chemical and biological characteristics of water via statistical sampling (Sanders et al., 1987). Monitoring provides information that permits rational decisions to be made on the following; describing water resources and identifying actual and emerging problems of water pollution, formulating plans and setting priorities for water resource management, developing and implementing water quantity and quality management programmes and evaluating the effectiveness of management actions (Bartrams, 1999). This illustrates that water resource monitoring operates within a larger structure of policy decisions and management (DWAF, 2004) where governance plays a major role in the success of these water resource monitoring initiatives. Therefore water resource management cannot be separated from water resource monitoring.

Toonen (2010) defines water governance as a process through which we manage and govern water resources, and this is drawn from the fact that societies and/or communities have a vested interest in the water resources around them. The interaction within societies may involve power struggles for the simple reason that the various parties have an interest in the benefits and services associated with good water management which include; the availability of adequate water or protection against waterborne

diseases (Toonen, 2010). The importance that these water-related goods and services have in a society, and consequently the importance associated with power over water governance, tends to be reflected in the existing water governance arrangements. Water governance arrangements are part of a larger governance and government system, which reveals how countries have organized the protection of interests critical for their societies to thrive and survive (Toonen, 2010).

Teisman and Hermans (2011) build on this definition, stating that water governance refers to "the variety of organisations active with respect to a certain collective topic – in this case water – and to the vitality of the interactions (exchange, coordination, cooperation, control, intervention, conflict) between the variety of active organizations". The term 'water governance' is sometimes also used interchangeably with Integrated Water Resources Management (IWRM), although important links can be found between them, they are not synonymous (Tortajada, 2010). The definition of Rogers and Hall (2003) is no different from that of Teisman and Hermans (2011) and Toonen (2010) in that "Water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society" (Teisman and Hermans, 2011). Essentially, it is how a country manages its water resources that determine the health of its people, the success of its economy, the sustainability of its natural environment, and its relations with its neighbours (Global Water Partnership, 2002).

Rogers et al., (2003) are of the view that, a more thorough analysis of governance must therefore focus on all the actors and structures in place to make and implement the decisions that shape and regulate the lives of citizens. It must be noted that democratic governments have a different role to play, they need to provide the framework necessary for all parties to collaborate and operate efficiently, correcting or coping with external failures, and even guarding against their own possible failures through

checks and balances and the rule of law (Crosby and Bryson, 2005). Public institutions are in reality only one category of actors with a determining stake in national governance but the definition implies that governments at the national, regional and local level are main actors in a country's system of governance. Other actors that play an important role are; civil society, composed of Non-Governmental Organizations and Community-Based Organizations (NGOs and CBOs), donors, research institutes, religious groups, media, lobbyists, and individuals (Rogers et al., 2003). The common thread among these arguments is good water management that brings about tangible benefits to a country, thus good governance is a cornerstone on how to develop and manage water resources, and the delivery of water services at different levels of society (Global Water Partnership, 2002).

According to Ashton (2005), although his study has not comprehensively engaged in the particular context of water resource monitoring framework in South Africa, it does talk of the integrating biodiversity concepts with good governance to support water resource management. This research was undertaken mainly because literature on natural resource governance issues has often focussed more on social, political and institutional processes within the governance system itself and, until recently, little attention has been paid to the links between associated governance systems and ecological systems (Holling, 2001; Gunderson and Holling, 2002; Folke, 2003; Pollard et al., 2003; Walker et al., 2004). In addition to understanding biodiversity concepts as they relate to water resource management, (Ashton 2005) suggested that it is important to understand the dynamics of the governance systems that are in place, which determine how water resources are managed and how water policies are implemented.

However, in a different context for example, Mackay and Ashton argue the current water governance system in South Africa is still fragmented and has deep vertical boundaries between the sectors that interact with and/or

govern the various components of the hydrological cycle, as well as between scientific organisations working on different components of the hydrological cycle (MacKay and Ashton, 2004) and Donkor and Wolde (2011) are also of the view that there are many problems impeding integrated water resources use and management in Africa particularly including; a growing population that is putting pressure on land and water resources, lack of water resources data without which development planning, design, operations and maintenance can be done, inefficient mobilization of financial resources, inadequate human resources development. Other issues include, water scarcity and institutional fragmentation that result in uncoordinated planning for water development that encourages overlap of activities and waste of scarce resources. And their views have been mainly focussed on Sub-Saharan Africa and they discovered that African countries are at different levels of development and it would be desirable for each country to develop their own new approaches and strategies suited to their conditions (Donkor and Wolde, 2011).

However, Brown (2010) argues that water issues are often complex and governments battle to integrate social, economic and environmental aspects. This is because the government itself cannot collaborate effectively at the national, regional and local levels. The 2006 United Nations report states that collaboration between stakeholders external to government has been minimal if not strained while decision making becomes more difficult when water issues need to be resolved at national and committee level (UN, 2006). The lack of institutional clarity, as mentioned above is an indication of government failure as this almost always results in lack of accountability when it comes to service delivery; as a result, citizens have lost trust in their government's ability to manage water resources in a sustainable manner.

In South Africa, prior to 1994, most water management decisions were undertaken by the national government via a centralised, bureaucratic sys-

tem. This system was virtually inaccessible to the general public and did not allow public participation in decision-making processes (MacKay, 2003). The Constitution of South Africa (Republic of South Africa, 1996) introduced a new approach to public policy and hence to water management decision-making. Two central doctrines of the constitution are that people should participate in decision-making processes that affect them, and that national government mandates are most effectively carried out by the lowest appropriate levels of government in the Republic of South Africa (Ashton, 2005). These principles of inclusion and subsidiary support the generic principles of good governance: openness, participation, accountability, effectiveness, coherence, democracy, and integrity (adapted from European Union, 2001). In addition, Acreman (2004) suggests that good environmental governance should reflect our best understanding of the structure, functions, processes and variability that typify natural systems (Acreman, 2004). The water governance issue has been brought up time and again by various authors that illustrate that most governments are lacking when it comes to direction – setting, oversight, support and regulation of water sector, therefore, this research will draw heavily on what other researchers have tried to achieve in terms of developing frameworks to address the governance issues within water resource monitoring and water sector as a whole. One can actually see within this area of study the dominant views on governance of water resources. Also there have been considerable strides made within the field of public and corporate governance. However, little has been done in the area of developing good environmental governance systems (Young, 2002).

This is the basis of this study in that the water sectors of the world have neglected the area of governance especially in the field of water resource monitoring and therefore neglected to design governance systems that better anticipate, reflect and respond to changes in environmental components and processes.What is important here is that there is a discourse that is not being addressed and that is the discourse that relates

water resource monitoring in the South African context and these issues have been explored further in the next chapter (Chapter 2) in which the comprehensive theoretical perspective is discussed.

1.7 METHODOLOGY

For this study, qualitative strategies were used to collect, analyze and interpret study data. Key methodologies for data collection such as content analysis of policy documents, records and websites, semi-structured interviews with key informants and focus group discussions were used to retrieve data that will assist in answering the research questions, where participants' preferences, thoughts and behaviours will be captured in a systematic manner (Bhattacherjee, 2012). The respondents were drawn from a number of organizations and the study population was made up of technical and managerial staff from universities; water research institutes, water boards, the Department of Water and Sanitation and its regional offices and other government departments involved in monitoring South Africa's water resources. This research focussed on the current water resource monitoring system in South Africa to develop an in-depth understanding of the governance structures and the various decision making arrangements at various institutional scales (Young, 2002; Adger, Brown, Fairbrass et al., 2003).

Expert sampling was used in this study, where potential respondents were chosen in a non-random manner based on their expertise on the issue being studied. It was chosen mainly because experts tend to be more familiar with the subject matter; water resource monitoring and their opinions are credible. Other participants were discovered using snowball technique because the sample for the study is very limited to a small sub-group of the population. With the conceptual framework providing the structure, the data was synthesized into a narrative from which recommendations for strengthening water resource monitoring governance emerged. Moreover, it was envisaged that the data will

provide insights into to the performance of policies that, in many cases applies to different regions of South Africa and to similar governance challenges in other regions or contexts. A detailed description of the methodology is presented in Chapter Three.

1.8 SCOPE OF THE STUDY

Within the water sector, there are several related issues that can be studied such as catchment management agencies issues, water resource quality and quantity challenges and water services challenges and/or opportunities and many other factors that are pertinent to the water sector. However, the focus of this study is to investigate factors that are accounting for the non-existence of an effective and unified water resource monitoring governance system in South Africa. It was important to limit this study to water resource monitoring because it would not be feasible to extensively study all the water related issues in South Africa as it would take many years to complete. When conducting research of this nature there are different components that are important for inclusion in the study such as resourcing for water resource monitoring in terms of finances, skills development and infrastructural development.

Several factors related to the research design and its implementation could have limited the value and relevance of the study. One, the study would have benefited from a greater number of respondents to provide a more diverse and richer picture of the perspectives on water resource monitoring governance in South Africa. However, due to time constraints and inability to access some respondents over the research period the study was limited to 63 respondents from all over the country. The respondents accessed were, for the most part, knowledgeable on the dynamics of water resource monitoring and governance in South Africa such as managerial and technical staff in the DWS and their respective stakeholders, and thus the information provided was deemed sufficient to meet the goals of the research.

Also, the methods employed in conducting the research, particularly the approach used to analyze and interpret the data, can allow for what Yin (2009) refers to as “equivocal evidence” or “biased views” of the researcher which can influence the direction of findings and conclusions of the study. A researcher’s values are recognized as an influence on the overall research process, and can at best be managed and acknowledged by stating those values and applying research standards (Maas, 2011).

1.9 ETHICAL CONSIDERATIONS

Research involving human subjects is risky business but nonetheless conducted. For this type of research, ethical approval was required. Flowerdew and Martin (2009) suggest that ethical issues are a crucial part of the study that needs serious consideration. A full risk assessment for the proposed project in terms of safety is mandatory not only because it is required by the Faculty/School of the academic institution, but because ethical issues that may arise, have huge impacts on the entire research design and consequently on the quality of the research results (Gibson and Brown, 2009). Before the study commenced ethical clearance was sought to ensure that the study does not jeopardize the researcher, the supervisor, the University of the Witwatersrand, the Department of Water and Sanitation and the key informants of the various stakeholders. This was to protect the interest of all involved in this study from psychological, financial and social harm to avoid litigations. A copy is attached in Appendix G.

1.10 THESIS STRUCTURE

The remaining five chapters are organized as follows. ***Chapter Two*** is a literature review of the water resource monitoring landscape. It provides an overview of water resource monitoring, its development and implications within the global water sector. It first defines key concepts and then the history of water resource management science is presented to understand the global, regional and local water resource monitoring

governance setting. In ***Chapter Three*** the methodological considerations of the fieldwork are presented. This chapter will include a detailed description of the data collection, instruments as well as respondents and interview guides and a brief look at methodological reflections. In ***Chapter Four***, empirical findings are discussed which will describe the findings on water resource monitoring governance, with perspectives from DWS regional and national officials and their external stakeholders. ***Chapter Five*** is the analysis where the findings and meaning of the study are presented. It is here where the roles and responsibilities are discussed with reference to the current governance model. The chapter ends with a discussion on the entry points that could contribute towards formulating an effective water resource monitoring management system in South Africa. In ***Chapter Six*** the key discussions are synthesized and this chapter ends with recommendations towards further research and contribution to water resource monitoring governance research.

[1]CHAPTER TWO

THEORETICAL CONSIDERATION AND LITERATURE REVIEW

2.1 INTRODUCTION

Across the globe, fast urbanization and industrialization is leading to a steep increase in waste generation. This waste ultimately ends up in water resources and decreases the quality of the water. This situation coupled with increased water demand and climate changes leads to degradation of water quality and quantity (Trivedi, 2008). One of the ways to address these challenges is to formulate national policies and regulatory frameworks and their implementation and in addition set up monitoring networks that enable measurement of pollutants and other organisms that affect water resources adversely. Water resource monitoring is therefore important because it helps indentify environmental problems, establish priorities for pollution control efforts, identify and implement appropriate control measures and to monitor compliance with regulatory limits (Trivedi, 2008).

In view of the above, this chapter is dedicated to engaging existing literature that has been written around water resource monitoring and governance. It is important that when we talk about monitoring, we understand that monitoring does not occur on its own. Monitoring occurs within institutions, policies and strategies and gives rise to efficient water resource management. Therefore the researcher engaged with arguments that have been written about the importance of institutions, monitoring

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[1]This chapter is based on a paper submitted to the journal WaterSA and is under review.

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itself as a concept and then applied this concept and how it relates to water resources management in a broader spectrum. Furthermore, the researcher engaged with the contemporary and prevailing arguments on water resource monitoring in South Africa.

In view of this, the review is structured in the following manner; section 2.2 defines key concepts and terms and establishes the context for the thesis with definitions of Integrated Water Resource Management (IWRM), water governance, sustainable development and water resource monitoring. Section 2.3 engages with water resource management and monitoring in a broader perspective particularly from a global perspective. Section 2.4 engages with water resource monitoring within the context of developing countries particularly in the context of Sub-Saharan Africa and section 2.5 looks at water monitoring and the work that has been done within context of South Africa. Finally, section 2.6 addresses the gaps in knowledge and is important because it provides the objective basis on which to identify opportunities for improvement or take corrective actions to improve water monitoring governance. The literature and theoretical frameworks offer useful theoretical and conceptual linkages which were employed and adopted as a basis for the development of a water resource monitoring framework for South Africa.

2.2 DEFINITION OF KEY CONCEPTS AND TERMS

There are a lot of concepts that have been used and engaged within this dissertation and the section therefore attempted to define what these concepts are and how they are being employed in this study. In order to understand the relationship between water resource management and water resource monitoring it is important to understand the key elements: integrated water resource management, sustainable development, water governance, and water resource monitoring. Though not mutually exclusive but often used interchangeably, these concepts mark the progression and impacts of current and emerging threats on quality and

quantity of a country's water resources within the water resource monitoring sphere. With the understanding that inadequate or insufficient monitoring information have consequences that could result in expensive remediation activities that might have been avoided had good quality information been readily available. Each of these elements has its place in literature and there has often been confusion regarding the definitions. An understanding of these elements is important for water resource management research. As a result of conflicting perspectives, the water resource monitoring literature allows for a range of definitions of these terms in relation to water resource management research.

I. Integrated Water Resource Management

Integrated Water Resource Management (IWRM) according to the World Water Development Report means "a process that promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. It implies that all the different uses of water resources are considered together" (World Water Development Report 2012). This concept was borne out of the 1992 Dublin principles of which subsidy and participation of water users in management are important elements. IWRM is used interchangeably with Water Resource Management, their definitions are very similar, although WRM explicitly makes reference to public stewardship and water governance and IWRM is based on integration of a variety of concepts including stakeholder involvement, equity and sustainability. The term "integrated" allows for involvement and/or participation by a wide variety of stakeholders that ideally should have a common understanding of IWRM so as to promote information exchange and help to match needs for solutions to water problems with available tools, assistance and resources (GWP, 2000). Thus, effective water resource management should be seen as a function of facilitated

cooperation, joint responsibility and integration within governance systems (Edelenbos and Teisman 2011).

II. Water Governance

Roger and Hall (2003) define water governance as ‘a range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services, at different levels of society. However, water governance and water management are interdependent issues in the sense that effective governance systems are meant to enable practical management tools’ (Rogers and Hall 2003). Similarly, Bakker (2003) defines it as a ‘range of political, organizational and administrative processes through which communities articulate their interest, their input is absorbed, decisions are made and implemented, and decision makers are held accountable in their development and management of water resources.’ Bakker (2003) further acknowledges that water management and water governance are closely linked, he distinguishes the two concepts as; ‘water governance refers to the decision making process we follow, how we make decisions and who decides while water management refers to operational approaches we adopt, the models, principles and information we use to make those decisions.”. Governance can be broadly defined as processes and structures for social co-ordination and collective decision making (Newman, 2001). It answers questions of who decides and how? Wherein there are actors and their own interests, and also what the process is for resolving contrasting views among the actors and interests (Folke et al., 2005). In essence, governance is about roles and activities of various actors and institutions, and interactions among them, in terms of their collective influence on sustainable development of water resource monitoring for instance. There is a demand for effective and collective dialogue and responses to address the growing challenges of globalization, climate change, increased water use and water scarcity (Pachauri, 2008).

III. Sustainable Development

In 1987 the World Commission on Environment and Development through Our Common Future publication sought to address the problem of conflicts between environment and development goals by formulating a definition of sustainable development: “Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs” - World Commission on Environment and Development, 1987 (WCED, 1987). The introduction of sustainable development influenced many aspects of human development varying from natural resource management, policies and institutions aiming to conserve the environment, poverty and public health and economic planning. It has been embraced to varying degrees and under varying interpretations at global, regional and local levels including governmental bodies and private sector.

Sustainable development is essentially about effective integration of social, economic and ecological aspects at all scales from local to global, where compromises and sacrifices are unavoidable (Kemp *et al*., 2005). This thesis adopts a more comprehensive conception of sustainability that has emerged with the growing influence of governance concepts such as conflict, complexity and uncertainty. The concepts of conflict, uncertainty and complexity introduced by Holling (1996) to help us understand that human and ecological systems are dynamic; continuous change and surprise are inevitable. This change leads to uncertainty in natural resource and environmental planning and management (Holling, 1996; Mitchell, 2002).

Complexity refers to the “interdependence of natural systems and the ramifications of interactions of human activity with the natural environment which are complex.” Water resource managers and planners have “to understand the different components, processes, and their interactions very well to develop sustainable management and development strategies

for the specific system" (Mitchell 2002; O'Riordan 1996). The potential sources of complexity in water monitoring governance are; many actors with different interests (political priorities), and fragmentation in governance.

Uncertainty refers to the reality that planners and managers do not have complete information about all factors influencing the decision resulting from complexity. "Nevertheless they have to make decisions despite their lack of information, about the ecosystem, for which their decisions have consequences" (Ewert et al. 2004, Mitchell 2002). The potential sources of uncertainty in water monitoring governance are; unclear roles and responsibilities among various levels and agencies of government, changing environment (climate change) and from social elements – from the diversity of rules and institutions operating at various levels and the underlying mental models that influence stakeholder perceptions and actions (Pahl-Wostl, 2007; Jeffrey et al., 2006).

Conflict refers to the diverse and often conflicting values and perspectives usually involved in resource allocation and use of decisions. Conflicts arise inevitably, and planners and managers have to recognize and mediate between the conflicting sides. "This is associated with the intergenerational and intra-generational equity implied in the term sustainability" (Mitchell 2002). The potential sources of conflict in water monitoring governance are; competing interests, water demands versus resource needs. Rather than seeking to resolve the challenges posed by complexity, uncertainty and conflict, Mitchell (2002) suggests that we should "recognize their importance and determine how to function in their presence."

IV. Water Resource Monitoring

The International Organization for Standardization (ISO) describes monitoring as "the programmed process of sampling, measurement and subsequent recording or signalling, or both, of various water

characteristics, often with the aim of assessing conformity to specified objectives" (ISO 9001:2015). Bartrams (1999) also describes monitoring as the main source of feedback data in the system of water resources management. It allows to determine quantitative and qualitative characteristics of water and to evaluate its suitability for certain kinds of usage. Both definitions clearly describe the process of monitoring as consisting of a collection of information at certain points, in certain time intervals, for obtaining data reflecting current situation and allowing the determination of trends in its development. Monitoring data still forms the basis upon which water quality management decisions are based and the design of monitoring information systems are aimed at ensuring high quality data for decision making (Grobler and Ntsaba, 2004).

2.3 WATER RESOURCE MONITORING: A GLOBAL CONTEXT

Across the globe, recent changes in climate, coupled with water pollution, weak governance structures and exponential population growth have resulted in increased water consumption thereby increasing stress on water resources which are already under pressure (Rana and Kelly, 2004). For example the impact of climate change will result in the reduction of surface water and groundwater resources mostly in subtropical regions which will in turn intensify competition among different subsectors of the economy like agriculture and industry (Jimenez et al. 2014). In the 2006 United Nations report, it was argued that the impending global water crisis is not just a water crisis but mostly a governance crisis of water resources (UN, 2006). Like all crises, as Meybeck (2003) observed, the sooner the scientific community works towards solutions, the less grave the consequences will be for now and future generations. In water services and water resource management, this manifests itself in "the fragmented institutional structures, the lack of clarity of roles and responsibilities, questionable resource allocation, patchy financial management, low capacity of implementing organisations; and in the pervasive leakage of

sector resources, weak accountability of politicians, policy-makers and implementing agencies, unclear or non-existent regulatory environments, and unpredictability in the investment climate for private sector actors" (UN, 2006).

As far as Plummer and Slaymaker (2007) are concerned; the global water sector has succeeded in developing technical solutions in recent years, but issues of governance were never really understood or explored. Meybeck (2003) pointed out that governance of the water sector is critical if the poor are going to have access to improved and sustainable water services, furthermore water issues are often complex and governments battle to integrate social, economic and environmental aspects. And this is mainly because most governments cannot collaborate effectively at the national, regional and local levels (Meybeck, 2003).

Collaboration between stakeholders external to government has been minimal if not strained, while decision making becomes more difficult when water issues need to be resolved at national and committee level (UN, 2006). Salman and Bradlow (2006) observed that many states are moving faster in the direction of adopting water resource legislation to address in detail the various emerging issues in the water sector. In addition, some countries that already have water legislation in place are realizing that there are key challenges that are not addressed in such legislation (Salman and Bradlow, 2006). It is around issues like these that the IWRM concept became popular, as it was envisioned that IWRM would assist in the management of water resources in terms of implementing policy and strategies, developing technology and capacity and generation of information through monitoring. While many countries are attempting to apply IWRM principles, there is still a lack of understanding of how IWRM works in different contexts (Biswas, 2004; Lubell and Edelenbos, 2013).

As Biswas (2004) pointed out that at first glance, water monitoring as part of the concept of IWRM as a whole looks attractive, a deeper analysis

brings out many problems, both in concept and implementation, to an extent that even when policies are reviewed or drawn up and commissions have been appointed, there is still a problem of implementation. Even in developed countries like Canada for example, according to Vaughan et al., 2010 in his Fall Report of the Commissioner of the Environment and Sustainable Development identified that Environment Canada as a ministry has not fully defined the extent of its monitoring responsibilities and therefore “cannot monitor water quality on the majority of federal lands and does not know whether other federal departments are doing so. As a result, there may be vast areas under federal jurisdiction where fresh water quality and quantity conditions are not being monitored” (Vaughan et al., 2010).Vaughan (2010) suggested that the above issue also shows that the Ministry (Environment Canada) has not systematically assessed client needs and therefore cannot supply the required data and/or information as required for sustainable water resource management in the country. Vaughan (2010) also pointed out that though policy recognizes the national government’s responsibility for developing and maintaining water data and information systems to help manage Canada’s water resources, it would be impossible to monitor all the water resources due to human and financial constraints, which is why the national government is committed to collaborations between the various government agencies and institutions. The Australian Council of Environment and Conservation’s approach was different in that a risk assessment which entails assessing potential impacts of declining water quality is used to identify the water resource that must be prioritized for monitoring (Australian Guidelines for Water Quality Monitoring and Reporting NWQMS, 2000).

Furthermore, in Canada, Vaughan (2010) discovered that human resources allocated according to specific regional needs, which puts them at a disadvantage should a new site be discovered as a hotspot for monitoring. Vaughan (2010) also pointed out that proposals were made to extend the programmes with additional human and financial resources but

did not receive any attention. In terms of human resource capacity in the Indian water sector, Kumar (2000) identified that when old staff retires, they are not replaced by newly recruited staff and that many state water departments (irrigation and water supply) have gradually stopped new recruitment. According to Kumar (2000), this leaves a low number of professionals and technicians to carry more and more responsibilities, which in turn results in the monitoring of fewer sites that limit their ability to put together timely management responses when needed.

In developing countries like India, the experiences show that institutional weakness and malfunctions are a major cause of ineffective and unsustainable water services (World Bank 2004; Saleth, 2005; TERI, 2006). Kumar (2000) suggests that India's water sector institutions are "designed and equipped to appropriate and develop and not to allocate and manage the water resources however the competing uses of water make it difficult to efficiently allocate water." Kumar (2000) also argues that the institutions compete with each other on "the amount of water they supply, coverage in terms of area irrigated or number of habitations covered, and the revenue collected from the same, and not in terms of the water available for environmental flows in the basin, or the quality of water in the river or the aquifer" and as a result they over-appropriate water from the resource. Furthermore, according to Frederiksen (1998) there is a duplication of functions with these institutions due to the flawed institutional design which in turn reduces the effectiveness of the institutions. However, his view counters the view of Kumar (2000) who argues that structure does not guarantee performance, however inappropriate structure is a virtual guarantee for sub-standard performance because there exists an explicit relationship between organizational structure and functions,.

With growing water scarcity, the priority of governments in the recent years has moved from water resources development and poverty eradication to water allocation and water resources management, overlooking water

resource infrastructure and monitoring programmes design (Kumar, 2000). Hamdy et al., (1998) is of the view that the main institutional challenge is to develop policies, rules, organizations and management skills which address both needs, i.e., water resources management and water allocation, simultaneously. While Kumar's viewpoint is that expansion and integration of national water resources planning is needed to comprehensively manage water resources and allocation of water, he acknowledges that the institutional capacity building of the agencies responsible for water resources and services management has not kept pace with the changing times (Kumar, 2000). Therefore, as Biswas (2004) pointed out, it would not be an exaggeration to argue that the challenge of weak governance structure is by far the most serious in management of water resources.

According to Kumar (2000), in addition to the lack of governance structures or inefficient governance structures, the lack of ability to integrate knowledge from other disciplines other than hydrology makes the issue more complex; "for instance, the irrigation departments, which deal with the bulk of developed water resources in the country, do not have professionals qualified in environmental hydrology, hydro-chemistry, agricultural sciences and irrigation economics". In Canada Vaughan (2010) found that of the two major monitoring programmes, only one -the National Hydrometric programme had clearly defined the responsibilities through formal arrangements of cost-sharing between the Department (Environment Canada) and each province (Vaughan, 2010). This meant that the other programme, the Fresh Water Quality monitoring programme, loses out on the benefit of a cooperative approach to water resource assessment; comparable, reliable, and accessible data across the country, consultation on the need for and use of data from each monitoring station, sharing of costs according to need and the exchange of information and expertise (Vaughan, 2010).

While in India for example; Kumar, stated that in recent years, the bulk of financial investment in the water sector has been construction centric, however, in as much as world class infrastructure is needed, the focus should be on “capacity building of the agencies which are mandated to undertake this work, which is necessary for physical, economic and environmental sustainability” (Kumar, 2000). It was identified through the Indian Ministry of Water Resources report in 2006 by Kumar that there is a shortage of funds to service the needs of water resources infrastructure, maintenance and management development as well as inappropriate allocation and/or prioritization of government expenditures (Kumar, 2000). Even in Canada where efficient monitoring programmes such as their Fresh Water Quality Monitoring Programme and the National Hydrometric Programme exist, monitoring can still be expensive as there are high costs associated with water resource monitoring over a large geographical area or over a long time frame (CESD, 2004).

In a review of Korea’s groundwater monitoring networks, Lee et al., (2016) found that there are a number of issues and problems that exist and need to be addressed. According to Lee et al., (2016) a comprehensive and integrated law is absent that should guide co-operation between ministries in terms of roles and responsibilities. And this manifested in the inability to share monitoring network data as different ministries have different formats with different communication protocols which makes it difficult to compare with other network data (Lee et al., 2016). Furthermore, the ministries and affiliated agencies lack communication with each other because each ministry develops a monitoring network for its own purposes almost independently, without sharing enough information with other ministries as to the well locations, well specifications, and monitoring devices.

Lee et al. (2016) suggests that holistic approaches among different ministries and agencies are required to secure groundwater resources of the country as the current practice raises a sustainability issue for the

overall monitoring system in Korea. Lee et al., (2016) also discovered that the missing element in the current monitoring system is active public participation and feedback. He argues that network data is used mainly for administrative purposes and/or academic research and generally the public are not involved in planning the monitoring network from the design step to the operation step as it impacts their livelihoods (Lee et al., 2016).

While all the above researchers have their perspective on water resource monitoring, there is a common thread of challenges, some speak of financial and human resource constraints, weak governance structures, lack of monitoring programme integrations and the lack of a user-centric approach which requires a monitoring programme to be defined according to specific information required for users to perform a stated water management function. However, none addressed speak of recommendations on how to improve governance arrangements for water resource monitoring.

2.4 WATER RESOURCE MONITORING: A REGIONAL SUB-SAHARAN AFRICAN (SSA) CONTEXT

According to Sheffield (2014), the population of SSA is over 870 million people and is expected to at least double by midcentury. Sheffield (2014) further argues that the burgeoning population coupled with expected overall drying with climate change, in particular in southern Africa and parts of West Africa (Sheffield and Wood 2008; Williams and Funk 2011; Seneviratne et al. 2012), there are worrisome implications for water resource sustainability and food security (Sheffield et al., 2014). Within many of the states in Sub-Saharan Africa (SSA), water sector reforms are taking place to align with the IWRM principles in the form of policy reviews, inception of new policies and establishment of new institutions (Swatuk, 2005). It must be noted that efficient management of water resources can only occur if we can measure and monitor the quality and quantity of water resources (Deming, 1986). In the context of SSA, the importance of water

resource monitoring as a development and resource tool is yet to be realized (Sheffield et al., 2014), and this is seen in the limited literature on water resource monitoring and the governance issues thereof.

Literature fails to provide information on water monitoring but rather seems to be anchored in water resource management. Water resource development policies and strategies cannot be realised without understanding the most important issue – the availability of surface and ground water and the occurrence of floods and droughts. This requires good information collection and dissemination which is the basis of water resource monitoring (Sheffield, 2014, SADC, 2006). For example, Sheffield et al., (2014) recognized the need for a drought monitoring and forecasting system in Sub-Saharan Africa because they understood that timely seasonal forecasts are essential for drought risk reduction in SSA where livelihoods are closely intertwined with climate variability (Tarhule and Lamb 2003; Amissah-Arthur 2003; Hayes et al. 2004; Hansen et al. 2011; Pozzi et al. 2013).

Sheffield (2014) argues that current approaches in developing countries have generally been limited in part, because of unreliable monitoring networks and lack of access to information and technology that prevents the development of systems locally, as well as generally low institutional capacity and lack of national policy on drought mitigation. In view of the above observation, in order to obtain reliable high quality data; data acquisition and dissemination systems must be in place for water resource planning and management (Malzbender and Earle, 2005). The SADC region does not have that luxury, instead it is faced with many water resource monitoring challenges as observed by Macatsha (2006) and illustrated on Table 2.1. Ongley (1997) is also of the view that the developed world has had the luxury of contending with environmental deterioration sequentially in time. While developing countries face major environmental issues like faecal contamination, acid mine drainage, toxic chemicals, eutrophication etc. simultaneously, in a strained economic

climate as well as poor institutional governance (Ongley, 1997). Compounding these challenges is that water resources in SADC region are unevenly-distributed compared to population and settlement patterns coupled with a variable and changing climate as observed by Macatsha (2006). Therefore water availability and water quality are critical concerns for many SADC member states (Sheffield et al., 2014)

Table 2.1 Overview of challenges in the SADC region and their possible impact on the water sector.

Challenge	**Impact**
Weak governance structures - No basis for capacity building to implement policies.	No formalized arrangements with stakeholders and lack of clarity on roles and responsibilities (CESD, 2012) "Inappropriate structure is a virtual guarantee for sub-standard performance" (Kumar, 2000)
Lack of financial resources - Due to lack of prioritization and ongoing theft and vandalism of water monitoring network equipment that is expensive to replace.	Lack of infrastructure sustainability, for building world-class infrastructure (Kumar, 2000) This impedes continuous water resource monitoring and results in gaps in data (SADC, 2006)
Lack of human resources - Technical staff is reduced because when old staff retires, they are not replaced by newly recruited staff and have unpleasant working conditions.	Inability to attract the level of expertise in terms of professional and technical staff that results in low human resource capacities. Cannot implement policies, strategies and prepare base for effective capacity building policy because the key to building institutional capacity is framing the right kind of water policies (Kumar, 2000)
Lack of monitoring integration - Lack of ability to integrate knowledge from disciplines other than hydrology into water resource planning and management	Duplication of monitoring functions among water resources development stakeholders (SADC, 2006) Higher training institutions not aligned with regard to curriculum changes (Kumar, 2000)

	Lack of integration of monitoring programmes in the SADC region resulted in the lack of agreed standard guidelines for minimum standards of water quality for regional ecosystems, which means they are not aligned and as a result cannot be interpreted correctly as they differ significantly (SADC, 2006)
Inefficient data management - Due to lack of training for data management and statistical tools to analyse the data for trend analyses and data validation.	Improper reporting of units, variation in analysis methods and quality control of chemicals are cause of concern (SADC, 2006, Bhardwaj, 2005) No validation of the quality of data disseminated (CESD, 2012) Monitoring programmes might not address information needs for clients as a result water quality data may not be fit for intended use (CESD, 2012)

Sources: Macatsha (2006), CESD (2012), Kumar (2000), Bhardwaj (2005) and SADC (2006).

It has been observed by Macatsha (2006), that SADC countries do not have appropriate water resource monitoring system in place and that what exists, is not aligned with international best practice recommendations. Consequently, the lack of appropriate water monitoring programmes could become one of the limiting factors to economic development in the region, for example; reduction in agricultural production, tourism and foreign investment on water-intensive industries (Macatsha, 2006).

It was however noted in the report titled; Water Resources of the SADC: Demands, Dependencies and Governance Responses written by Malzbender and Earle (2005), that most states in SADC region are undergoing some level of institutional transition where policies and legislature are under review. Issues arise in trying to harmonize policy and legislation and implementation in terms of how the changes will affect future arrangements and in understanding the place of traditional water management expertise and the involvement of stakeholders in decision

making (Malzbender and Earle, 2005). Macatsha (2006) also found that the lack of integration of monitoring programmes in the SADC region resulted in the lack of agreed standard guidelines for minimum standards of water quality for regional ecosystems, which means they are not aligned and as a result cannot be interpreted correctly as they differ significantly.

The importance of stakeholder participation in decision-making processes is a fundamental principle of IWRM, as captured by, *inter alia*, the Dublin Principles, cannot be overstated. Because it is "through the engagement of stakeholders that issues of local and regional significance are highlighted, that ownership of the process is transferred to the people that the process is affecting and that a consensual, people-oriented approach is pursued" (Malzbender and Earle, 2005). According to the 2006 SADC report, developing a monitoring and evaluation system that will address policy objectives and implementation is desperately needed. The monitoring requirements should be related to the Millennium Development Goals (MDGs) and the Johannesburg Plan of Implementation Targets from the World Summit on Sustainable Development (SADC, 2006).

In the 2012 status report on the Application of Integrated Approaches to Water Resource Management in Africa, Taylor et al., (2012) stated that; "Low social development often-times goes hand in hand where progress with resources management has been the lowest". This is true of most countries in Sub-Saharan Africa faced with sizeable and often shared development challenges when it comes to water access, management and supply (Freitas, 2013). Expansion of irrigation, industrialization and increasing urbanization has put tremendous pressure on the available water resources as noted by Wolde and Donkor (1997) and this highlights the fact that quantity and quality of available water is being reduced at an alarming speed.

Water resources data is important for water resource development planning, design, operation and maintenance (Wolde and Donkor, 1997)

and generating this data costs money. Taylor et al., (2012) went on to say that, meteorological and hydrological services are competing with other pressing needs and often lose out due to government budget constraints as collection and analysis of data have to be carried out with limited resources.. As a result, most African countries lack reliable data that would equip decision makers with the tools to help address the current challenges; moreover no strategies, programmes and plans for water resource management can be implemented (Taylor et al., 2012). Malzbender and Earle, (2005) also reported that vandalism and theft of data monitoring networks and/or equipment are part of the reasons why water resource monitoring has become more and more expensive over the years. And like other regions, there is inadequate coverage and poor operations and maintenance of hydro-meteorological networks due to low allocation of financial resources from national budgets (Taylor et al., 2012).

Winpenny (2010) suggests that there is also a shortage of policy analysis and guidance on the sustainable financing of water resource management by saying; “Evidence exists that in many countries water resource management is inadequately funded, partly because of general financial constraints where water competes with other pressing needs or more profitable uses of water and also because the benefits of water resource management are not fully understood.” He went on to say that in the near future, payment for the cost of managing water resources in Africa is likely to be covered almost exclusively from general taxation through budgetary allocations and the present levels are very low and irregular (Winpenny, 2010). Moreover, Winpenny (2010) suggests that governments should perform better and make budget allocations more predictable and timely, less arbitrary and more consistent year by year to ensure sustainability, financing may require diversification of funding sources, to include cost sharing and charges raised on direct beneficiaries. . Winpenny (2010) further argues that in the developing world in general, efforts to generate revenues through permit application fees, water quality laboratory

analyses and annual fees for abstraction and discharge permit holders have so far not resulted in substantial income and in turn, there are no funds to maintain and manage water resources.

Malzbender and Earle (2005) reported low human resource capacities especially qualified professional and technical staff of national hydrological services. And one of the reasons was the fact that unattractive working conditions made it difficult to even recruit professionals of that calibre into water resource monitoring activities (Malzbender and Earle, 2005). Kumar (2000) also noted that travelling long distances for monitoring made it difficult not only for the professional's' safety but for preservation of samples in warm weather conditions that could ultimately affect the results. Having said that, it is important to note that data management plays a crucial role in the cycle of water resource monitoring as data should be collected and analysed correctly and thereafter disseminated as information to the right people at the right time as alluded by Kumar (2000).

Kumar (2000) goes on to suggest that inefficient data management stems from a lack of basic training. One of the questions he asked was; "are the training institutions designing curriculum according to knowledge gaps and country needs?" (Kumar, 2000). Kumar (2000) also noted that the organizations existing to impart training in the specific sectors are often criticized for lack of advanced technical knowledge and skill orientation to impart training and recommended that wherever knowledge/skill gaps exist, new research studies be commissioned. Kumar (2006) does however admit that it would be a long-drawn process, but worth starting, especially with "the vital database on water resource availability and water quality accessible to the local community. The concerned actors (like the municipality or an industrial unit) would become more accountable to them, thereby directly impacting on water governance" (Kumar,2000).In the Canadian context, Vaughan (2010) indicated that most monitoring programmes lack standard procedures to assure that the quality of the

data it disseminates from its regional databases is reliable. Vaughan (2010) goes on to say the Environment Canadian ministry is heavily reliant on the provider to assure the quality of the data it receives and in essence do not really know whether the information disseminated is an accurate reflection of ecosystem health. Malzbender and Earle (2005) suggest that data dissemination between countries, especially those with trans-boundary water resources, promotes collaboration between shared watercourse states in terms of water resources development and management. They further state that in a perfect world, different states trust one another and have confidence in the data integrity (Malzbender and Earle, 2005). An important part of water resource management is the assessment or analysis of data which requires highly qualified and experienced staff as it involves economic, environmental, legal and social aspects and that in itself presents a challenge because different states in the SADC region employ different methodologies (Malzbender and Earle, 2005). In other words, there are no common standards, when it comes to water resource assessment and what makes the situation complex is that most of this kind of work is outsourced from private institutions i.e. Professional Service Providers instead of the national government staff (Malzbender and Earle, 2005). It comes back to the issue of unskilled staff and the unattractiveness of the jobs in the water resource monitoring section of the water sector as stated by Kumar (2000) earlier.

Malzbender and Earle (2005) suggest that integration of monitoring programmes may be the answer to some of the institutional challenges that many countries face as this will eliminate duplication and gaps in information collection, particularly if they also draw on supplementary information collected by other stakeholders external to the government. However, they are also of the view that government must still keep the responsibility for setting priorities for monitoring and reporting to meet nationally agreed objectives. Generally, literature on Sub-Saharan Africa indicates that water resource monitoring frameworks in developing countries are lacking in certain areas. It was found that while the

institutional frameworks exist, not all policies, programmes aimed at improving management of water resources, are implemented. As a consequence, the governments have no objective basis on which to identify opportunities for improvement or take corrective actions to improve these monitoring programmes and quality of water resources (Ongley, 1997). Within the continent of Africa there has been an effort that has been made in terms of water resource management research, however the monitoring aspect has not been comprehensive, and we need to understand the formulation and strategies and policies that guide the water resource monitoring frameworks.

2.5 WATER RESOURCE MONITORING: A SOUTH AFRICAN CONTEXT

The National Water Policy states that 'ongoing monitoring and assessment of the patterns of resource use, and the response of the resource to use, are critical for effective resource management and protection' and should be based on sound scientific and technical information and understanding where the monitoring and information management function is defined as a national government competency (DWAF, 1994). While Chapter 14 of the National Water Act of 1998 is dedicated to the integration and co-ordination of monitoring systems by the Minister, where the Minister is mandated to establish national monitoring systems and national information systems on water resources for the information produced by the monitoring systems; ensure access to this information; and establish mechanisms to coordinate monitoring (DWAF, 1998).

Prior to the reform of water laws, as noted by Nomquphu et al., (2007), previously, water resources management in South Africa was highly centralized and largely supply driven (i.e. dam construction, inter-basin transfers and irrigation schemes) and primarily supported the provision and allocation of water for development in the agricultural, urban and mining sectors (MacKay, 2003). With the pressures of economic

development, this made a compelling case for the country to embark on a comprehensive reform of water policies and institutions guided by Integrated Water Resources Management (IWRM) principles to ensure the equitable and sustainable utilization of this increasingly scarce resource (DWAF, 2008b). Furthermore, Nomquphu's (2007) viewpoint was that water resource monitoring was previously intended to support the development and operation of the national water infrastructure. However, it now focuses on compliance with resource quality objectives, management targets and water use licence conditions at national, regional (catchment) and local levels (Nomquphu et al., 2007). This change in the water resource monitoring environment requires consistent and systematic measurement of water quality and quantity parameters to measure impacts, extent and rate of climate change, water scarcity, increased water use and urbanization. As South African water resources become scarcer and the impacts of increased water use are compounding the management of water resources in terms of uncertainty and complexity; this often leads to increased potential for conflict among the many stakeholders with interest in water resources (DWAF, 2008).

Nomquphu et al., (2007) argue that based on national considerations and international best practice (Ongley, 1997; Timmerman, 2000; Peters, 2003), the current strategic framework for water resource monitoring in South Africa aims to harmonize and integrate monitoring systems. Ashton however examined the existing governance systems and current understandings of biodiversity provided evidence to suggest that a far closer alignment between a particular governance system and the biophysical components and ecological processes comprising a specific environmental system that supports society could significantly enhance our systems of environmental governance (Ashton et al., 2005). In short Ashton (2005) suggested that integrating biodiversity concepts with good governance would help support water resources management in South Africa.

According to Ashton et al., (2005), South Africa's water governance system remains somewhat fragmented because of the need for separate management approaches to address different environmental components of the hydrological cycle despite recent reforms in its water policies and legislation (Ashton et al., 2005). Ashton argues that the scope of governance in the water and environmental context includes the full suite of mechanisms for managing water and other natural resources according to objectives that reflect the goals of society (Ashton et al., 2005). They goes on to say that it should include all three sectors of society: government, Non-Governmental Organizations, and community or civil society (including private and commercial sectors) which are stratified into different levels, form international, regional and national down to local (Ashton et al., 2005). And in this manner, cooperative governance between and among sectors is essential because of the interaction between different ecosystem components. In other words, different components of the hydrological cycle spread amongst several agencies at different levels of government (Ashton et al., 2005). Ashton et al., (2005) also suggested that in the future, a greater emphasis will need to be placed on increased levels of co-operation between relevant governance systems related to water, as well as increased trans-disciplinary research that can better define the links between environmental governance systems and ecological systems. .

Nomquphu et al., (2007) is of the view that the South African water resources management model as per the National Water Resource Strategy I, is conceptualized along similar lines and this, in turn, has provided perspective on the nature of the future governance of the country's monitoring activities .He argues that the key to successful implementation of water resources management is the systematic flow of relevant, up to date information generated throughout the hydrological cycle between governmental sectors with specific legislative responsibilities for certain components of the hydrological cycle (Nomquphu et al., 2007). Again, this requires sound cooperative

governance where two or more social actors negotiate, define and guarantee amongst others themselves a fair sharing of the management functions, entitlements and responsibilities for a given territory, area or set of natural resources (Borrini et al., 2000) as Ashton (2005) has already alluded to.

Nomquphu (2007) argues that a much stronger, science-led water resources management approach will be needed as the focus shifts from point-source control to optimization of resource conservation use for a variety of societal needs.. This would include for example the use of indicators to gauge the sustainability and efficiency of a systems approach to water resources as suggested by Gorgens (2003). Gorgens (2003) argues that strategies promoting sustainable utilization of a resource would fail if they did not recognize that the resource resides in, or comprises, an input transference system with many components, qualities and links and thereby declaring that 'systems' by definition imply a focus on the integration of different components operating at different levels (Gorgens, 2003).

In his thorough study of the science-led River Health Monitoring Programme (RHP) in South Africa, Nomquphu et al. (2007) showed that partnerships and voluntary co-operations are starting to happen where social actors are drawn from all levels of government; the science community and civil society are involved. Furthermore, the public-private partnership demonstrated in the RHP provides an approach to governance which allows the industry to monitor itself and be accountable for its own performance, while the regulating authority (currently the Department of Water and Sanitation) focuses on auditing and penalty action where necessary. And this is how the conceptual model for the co-ordination of water resources monitoring activities in South Africa was born. As described by Nomquphu et al., (2007), it consists of the following components; national level where the proposed advisory committee on water information will determine high-level strategic information needs and

formulate policy for water resources information management, the National Water Resource Quality Monitoring Committee where all monitoring programmes (national and local) are co-ordinated and integrated in terms of a national monitoring framework supported by technical sub-committees; and the regional nodes of co-ordination built around DWS clusters or regional offices to co-ordinate the management of their portion of the national programmes, facilitate co-operation between various monitoring networks and promote the sharing of information among all organizations involved in monitoring of water resources (Nomquphu et al. 2007).

Some water resource monitoring challenges that have been described by Grobler and Ntsaba (2004) in the publication; Strategic Framework for National Water Resource Quality Monitoring Programmes are as follows; a severe lack of capacity especially where water resource quality is concerned. They also pointed out that water resource planners and managers within the DWS and outside of DWS complained about the lack of relevant water resource quality information to support their planning and management information needs (Grobler and Ntsaba, 2004) which causes 'data-rich but information-poor' syndrome where masses of data are being collected requiring time, effort and money seemingly without the expected benefits being derived from it. The data-rich but information-poor syndrome led several countries (USA, Europe, New Zealand, and to some extent, South Africa) to fundamentally rethink the purpose of water resource quality monitoring, and consequently the process being used to design monitoring programmes (Grobler and Ntsaba, 2004). Furthermore, there is poor coordination and even conflict between different groups involved in water resource quality monitoring which results in duplication of effort and human and financial resources as noted by Grobler and Ntsaba (2004).

However, Grobler and Ntsaba (2004) have also noted that a key success factor for effecting monitoring of water resource quality as prescribed in

the NWA will be effective governance of the overall process (Grobler and Ntsaba, 2004). The governance process must coordinate and share resources, infrastructure, data and information across the various water management institutions involved, ensuring information delivery at the three management tiers (national, regional and local). Grobler and Ntsaba (2004) assert that the governance process must;

I. Adopt common standards for the performance of data acquisition, data management and storage, and information generation and dissemination,
II. Implement common quality assurance criteria across the different tiers at which monitoring is performed,
III. Effectively share scarce and difficult to maintain resources, such as the Information Technology (IT) infrastructure supporting monitoring functions, i.e. data acquisition, data management and storage and information generation and dissemination,
IV. Support ongoing research and development of technologies (methods, standards, instrumentation, etc.) required to maintain cost-effective monitoring programmes. This should be done at the national tier,
V. Coordinate all the relevant activities of stakeholders (inside and outside DWAF) involved in water resource quality monitoring (DWAF, 2004; Grobler and Ntsaba, 2004).

There is a common thread of governance issues as described by different authors on a global, regional and local level where water resource monitoring is concerned which needs to be investigated further to understand why this is so.

2.6 GAPS IN KNOWLEDGE

Research on the subject of water resource monitoring has mostly been restricted to limited comparisons of water resource management on a

global, regional and local level. Literature reveals that up to now, very few in-depth studies exist on the subject of water resource monitoring; compared to the many studies conducted on water resource management. While water resource management covers the utilization and development of water resources in an efficient, environmentally sound, equitable and reasonable manner in order to satisfy society's demand for water, one should also keep in mind that water resource monitoring is an essential tool within effective integrated water resource management and needs to be explored and understood in order to inform governance and policy-making and help identify priority areas for action (Wolde and Donkor, 1997).

Monitoring systems in relation to water governance reform is an area which is underdeveloped and tends to be neglected by decision makers in the water sector. The integrated approach to water management places further strain on monitoring systems as they involve a shift in mind-set from primarily monitoring hydrological data to data related to water use and policy processes and implementation (OECD, 2013). One of the biggest concerns is that water activities, including monitoring are often split between a number of ministries and departments at the national level. This fragmentation of responsibilities among sector based ministries and administrative agencies hinders co-ordination and hampers attempts to integrate water management activities. "As a result, there is a need for capacity building within institutions to develop financially viable systems, to design policy structures which can respond to economic situations and avoid duplication of responsibilities" (Wolde and Donkor, 1997). However, few writers have been able to draw on any systematic research into the water resource monitoring governance challenges.

This study thus adds to existing scholarship on the fundamentals that need to be adhered to by policy actors wishing to build sustainable and integrated water resource monitoring framework in the regional (Sub-Saharan Africa) and local (South Africa) context. The study also generates

more evidence to demonstrate why participation in water resource monitoring in developing countries may not achieve its intended goals if stakeholders are not given the platform to voice their views and supported and guided by the DWS. At policy and practice level, the study uses evidence generated from a qualitative mixed methods study design to argue for sustainable and integrated water resource monitoring framework which ensures that governance structures in place are strong and effective.

A review of the literature shows that implementation of water law reforms, national water resource strategies and water monitoring governance models has been sluggish which in itself has perpetuated problems that existed at the time that the policies were developed; and also intensified the problems associated with the management of the water resources and water supply and sanitation. “Uncertainty related to the institutional framework and the status of the reforms has negatively affected water resources management performance and outcomes, staff morale, recruitment and retention, and accountability” (IRR, 2008). Sustainable water resource monitoring requires a holistic and integrated approach. Although South Africa is an experienced leader in the SADC region with regards to water resource monitoring, it still faces challenges in efficiently developing and managing its water resources sustainably. Therefore; there is a need to continue developing its water resources to match the growing economy and population and re-assess the current water resource management institutional frameworks to address the critical issue of water resource monitoring. That would in turn, lead to accountability and a sense of responsibility towards conserving valuable water resources in the country.

CHAPTER THREE

METHODOLOGICAL CONSIDERATIONS

3.1 INTRODUCTION

This chapter is devoted to the methodological considerations and issues within the context of the study. This study falls within the social sciences where the "*research encompasses the problem of inquiry purposes which lies in finding and selecting artefacts, then in analysing and interpreting them"* (Robson, 1993). In the case of this study, the artefacts are the selected respondents whom are actively involved in water resource monitoring and management thereof. The word 'methodology' derived from Greek means, "a rational way or journey undertaken in pursuit of some specified goal" (Dann, Nash and Pearce, 1988). In research, methodology is a systematic way to solve a problem in essence; it is a science of studying how research is to be carried out (Kothari, 2009). The procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology (Rajasekar et al., 2013). It is also defined as the study of methods by which knowledge is gained and its aim is to give the work plan of research. It is necessary for a researcher to design a methodology for the problem chosen, know how to apply it and evaluate the suitability (Rajasekar *et al*., 2013). Research methodology is usually concerned with a number of things among which include (see Rajasekar et al., 2013); (i) the reason a particular research study is undertaken, (ii) how the research problem is formulated, (iii) the type of data collected, (iv) the particular method that is used, (v) the particular technique used to analyse data.

In view of the themes and objectives of the study, this chapter is divided into the research philosophy which will provide the background and rationale for the methodology, recapping the research aims and objectives, research design which describes the research site, study population and sampling procedure, data collection tools and data analysis

which provide the rationale for subject selection and how the results will be analysed. Added to this, further methods used to answer the research questions such as the use of explanation building and pattern matching as data analysis tools is also detailed in this chapter. Lastly, the methodological reflections are presented where the challenges and research experiences are shared.

3.2 RESEARCH PHILOSOPHY

The philosophy employed in this research is a hybrid of positivism and interpretivism (Galliers, 1991). Positivism relates to the viewpoint that the researcher needs to concentrate on factual knowledge gained through observation that involves application of scientific methodology (Bhattacherjee, 2012). Positivists believe that reality is stable and can be observed and described from an objective viewpoint, in other words, without interfering with the phenomena being studied (Levin, 1988). Hughes (2001a) explains that the positivist paradigm sees the world as being based on unchanging, universal laws and the view that everything that occurs around us can be explained by knowledge of these universal laws. To understand these universal laws we need to observe and record events and phenomena around us in a systematic way and then work out the underlying principle that has 'caused' the event to occur.

According to Levin, (1988), positivists also believe that phenomena should be isolated and that observations should be repeatable. This often involves manipulation of reality with variations in only a single independent variable so as to identify regularities in, and to form relationships between, some of the constituent elements of the social world. "In positivism studies the role of the researcher is limited to data collection and interpretation through objective approach and the research findings are usually observable and quantifiable" (Collins, 2011).

According to the principles of positivism, it depends on quantifiable observations that lead themselves to statistical analysis. It has been noted

that “as a philosophy, positivism is in accordance with the empiricist view that knowledge stems from human experience. It has an atomistic, ontological view of the world as comprising discrete, observable elements and events that interact in an observable, determined and regular manner” (Collins, 2011).

Interpretive researchers on the other hand, believe that reality consists of people’s subjective experiences of the external world; which leads to the belief that reality is socially constructed. Interpretive theory is governed by observation and interpretation, therefore to observe is to collect information about events, while to interpret is to make meaning of that information by drawing conclusions or by judging the match between the information and some theoretical or conceptual pattern (Aikenhead, 1997). It is an attempt at trying to understand occurrences through the meanings that people assign to them (Deetz, 1996). In other words, as a mode of analysis, it suggests a way of understanding the meaning or trying to make sense of textual data which may be unclear in one way or another in context (Reeves and Hedberg, 2003).

An interpretive researcher uses meaning oriented methodologies versus measurement, such as interviewing or participant observation, that rely on a subjective relationship between the researcher and subjects. There are no predefined dependent and independent variables in interpretive research as it focuses on the full complexity of human sense making as the situation emerges (Kaplan and Maxwell, 1994). This is the interpretive approach, which aims to explain the subjective reasons and meanings that lie behind social action.

According to Willis (1995) and Walsham (1993), interpretivists believe that there is no correct route or single route or particular method to knowledge. They attempt to derive their theories from the field by an extensive examination of the phenomenon of interest. While Gephart (1999) argues that interpretivists believe that knowledge and meaning are acts of

interpretation, “hence there is no objective knowledge which is independent of thinking, reasoning humans” (Gephart, 1999). Myers (2009) also argues that the basis of interpretive research is that “access to reality (whether given or socially constructed) is only through social constructions such as language, consciousness and shared meanings” (Myers, 2009). Interpretivists are not interested in generating new theories but in judging or evaluating, and refining interpretive theories. According to Walsham (1995), there are three different uses of theory in interpretive case studies; theory guiding the design and collection of data; theory as an iterative process of data collection and analysis; and theory as an outcome of a case study. The use of theory as an iterative process between data collection and analysis has been applied in this research study.

Post-positivists argue that using more than one method when undertaking social science research may have its advantages depending on the subject matter to be addressed and that the approach should assist to get a clearer picture of the social world and for more passable explanations (Golafshani 2003). The combination of methods allows for weaknesses or biases to be minimized and the way this can be achieved is through theory testing and theory building through extension, convergence and contradiction of findings (Denzin, 2012). Failure to utilize such methods results in missed opportunities (Grafton et al., 2011).

Graton et al. (2011) and Dick, (2004) further argue that by combining methods and experimental information, researchers can hope to overcome the weaknesses or inherent biases and issues that arise from single methods and single theory studies. The underlying epistemology is positivist, an objectivist stance; and interpretive approach which guides the qualitative research, in other words, a hybrid of these perspectives underpins this research. The approach assumed here recognizes:

I. the need to identify objectives applicable to the study, what the issues are, how they were resolved and what actions should be taken to respond to those issues;
II. that there are unavoidable uncertainties linked to the understanding of how the world works because of complex relationships;
III. the need to explore a case that can be used to draw conclusions and recommendations based on the complex views of those most intimately associated with the case being studied.

In the context of this study, participants construct their own knowledge within the social-cultural context influenced by their prior knowledge and understanding, and therefore, the researcher positions himself as a researcher within the limits of an interpretive epistemological discourse. The environment within which the researcher is studying has to be created in such a way that there is a close relationship between the researcher and what is being studied and the participants are able to express their individual experiences in the process. This type of environment affords the researcher the means to observe, investigate and understand the process, gather and document participant experiences using tools such as participant observation, face-to-face with individuals as well as focus-group interviews in a social and cultural context.

The relevant key words for this methodology are participation, collaboration and engagement (Henning, van Rensburg, and Smit, 2004). Where the researcher does not stand above or outside, but is a participant observer who participates in the activities and understands the meanings of actions as they are expressed with specific social contexts (Carr and Kemmis, 1986). In line with the qualitative research design practices, this study ensured the necessary thoroughness in its design and implementation so as to increase reliability and validity of the research results. One of the most important characteristics of this effort was self

awareness and mitigation of the influences and biases the reseacher's predispositions can have on the research process and ultimately on the results. This is what is known as reflexivity in the research process.

Reflexivity is important because it is one of the pillars of critical qualitative research (Fontana, 2004) and relates to the "degree of influence that the researcher exerts, either intentionally or unintentionally, on the findings" (Jootun, 2009). While Carolan (2003) is of the opinion that "reflexivity is a term that is widely used, with a diverse range of connotations, and sometimes with virtually no meaning at all"; other authors (Parahoo (2006), Primeau (2003) and Hertz (1997) tend to agree that reflexivity does indeed "enhance the quality of research through its ability to extend our understanding of how our positions and interest as researchers affect all stages of the research process" (Primeau, 2003) and moreover, it is "a continuous process of reflection by the researcher on his or her values, preconceptions, behaviour or presence and those of the participants, which can affect the interpretation of responses and this involves researchers recognizing that they are part of the social world under study" (Hertz, 1997). Hertz (1997) further attests to the fact that reflexivity implies a shift in our understanding of data and its collection, and is achieved through detachment, internal dialogue and constant scrutiny of 'what I know' and 'how I know it'(Hertz, 1997).

From all the above interpretations of reflexivity one realizes that it is therefore, vital that as a researcher, one should enter the researches with the right instruments and ignore any pre-conceived ideas about that topic. The primary role should be to prompt, probe and encourage participants' views of their experiences. Overall, the credibility of one's research increases with the understanding of how one's own values and views may influence research findings because by bringing to consciousness the researcher's beliefs, he or she is in a position to approach the topic honestly and openly (Jootun 2009).

An attempt was made to ensure that the researcher's outlook and experiences did not have a substantial effect on the research process, and in process and in turn, the validity and reliability of this work in this chapter, and the rest of this thesis. In as much as one does not want to influence the outcome significantly, it is unrealistic to imagine that there are no advantages in incorporating the researcher's social self. This allows for engagement with participants and enrichment of the quality of research (Jootun, 2009). As Jootun, describes it; "while the researchers' reflexivity is imperative for the research process, one should be aware that total detachment is an unrealistic aspiration that can limit and hinder the qualitative process" (Jootun, 2009).The researcher's experience in the water sector helped to better understand the policies and the social issues in terms of the current framework and its origin. And this cannot be overlooked as the experience significantly shaped the researcher's professional and academic career, interests, beliefs and world views.

3.3 RECAPPING THE RESEARCH AIMS AND OBJECTIVES

Before discussing the methodology it is important to recap the key research aim and objectives that influence the study under which the methodology is anchored. The overall research aim for this study was to investigate the sustainability of the current South African water resource monitoring framework and explore the role of institutions in water resource monitoring. And the overall objective of this study is to understand the challenges that currently exist within water resource monitoring in South Africa which will serve as background for a proposed framework for future water resource management. And these elements are important because the methodology is developed around the aims and the objectives.

3.4 RESEARCH DESIGN

For this study, a qualitative mixed method research design was adopted where a range of qualitative methods were triangulated with questionnaires and interviews targeting DWS employees (regional and national) as well as DWS external stakeholders in South Africa. In particular, the study sought a deeper understanding of what factors play a role in institutional fragmentation that impedes the formation of a comprehensive management system of water resources monitoring.

This study considers the relevance and contextual applicability of commonly held philosophies or viewpoints around water resource monitoring governance using a theoretical framework mainly derived from organisation and management theory. Moreover, the study held an underlying proposition that enforcing deliberate measures to enable sustainable water resource management through monitoring in a missing ingredient of the existing governance framework in the broader context of South Africa's water policy framework (Stake, 1995). The water resource monitoring system in South Africa is recognized to be less than efficient, resulting in significant challenges and major negative impacts on other areas such as water allocation and public health issues which are, in turn, leading to potential conflict among the governance actors. Governance arrangements are evolving to include more decentralized and participatory decision making in the form of Catchment Management Agencies.

The study focuses on organizations in the water resource monitoring space and their roles and responsibilities. It is not geographically specific; however it involved reviewing the policy documents that are related to water resources which were obtained through different ministries and different stakeholders. Moreover, it involved engagement with experts working in the water sector in particular looking at the technicians and managers. It was important to engage certain organizations in the water sector namely;

The Department of Water and Sanitation was chosen because they should be the water sector and regulator according to the National Water Act (36 of 1998) specifically Chapter 14, Water Services Act (108 of 1997) specifically Chapter 10, and the NWRS2 specifically Chapter 13. With regards to water resource monitoring, the DWS should ensure that currently designed monitoring networks provide adequate data and information optimised for maximum synergy through a systematic water resource monitoring integration plan. In addition DWS develops policies, strategies, frameworks, standards, procedures and guidelines to support water monitoring.

Another institution which was important to include in the study was Catchment Management Agencies because they co-ordinate the related activities (which include water resource monitoring) of water users and of the water management institutions within its water management area. Furthermore, they investigate and advise interested persons on the protection, use, development, conservation, management and control of the water resources in its water management area.

Rand Water was chosen because the Department of Water and Sanitation duly represented by the Minister of Water and Sanitation is the sole shareholder. Also the relationship between Rand Water and its shareholder is governed by the provisions of the Water Services Act No 108 of 1997. This relationship introduces unprecedented complexities within the water resource monitoring environment; however, this will be discussed in detail in Chapter Five. Moreover, Rand Water monitors the Vaal catchment due to their business interests as their other major roles are purification and distribution of potable water from the Vaal dam.

Some respondents were drawn from the following municipalities, Tshwane, Ekurhuleni and Umngeni municipalities. These specific municipalities were chosen because they are concerned with the establishment or procurement, where appropriate, operation, management

and regulation of a potable water supply system. Including the services and infrastructure required for the regulation of water conservation, purification, reticulation and distribution; bulk supply to local supply points, metering, tariffs setting and debt collection; and provision of appropriate education so as to ensure reliable supply of a sufficient quantity and quality of water and effective water use amongst end-users, including informal households, to support life and personal hygiene. However, they are currently struggling to monitor and report on the water resources in their jurisdiction.

Universities and other research institutions were included in the study because they are currently piloting projects around water resource monitoring and information systems. For example, UNISA has undertaken a project to design monitoring networks that are optimally designed to address rainfall data monitoring for climate change (Pers. Comm., 2015cc). And CSIR is involved in Inkomati Catchment water resource monitoring, Department of Water and Sanitation (DWS) drinking water quality monitoring, Eskom-Lethabo Power Station water monitoring, ESKOM-Kusile power station water monitoring and Rand Water audit monitoring (Pers. Comm., 2015ff). And the Water Research Commission (WRC) supports the knowledge base in addressing impacts such as climate change, population growth and urbanisation on water resources. They focus on institutional arrangements, reform and governance, catchment assessment and planning, water quality management, water resource protection, to water resources and climate change. In the case of water governance and institutional reforms, the focus is on articulating the thinking for the new roles and responsibilities of the various stakeholders, based on catchment and water management area boundaries (Pers. Comm., 2015aa, www.wrc.org.za/wrcknowledgereview2014/15. p10 -49).

The involvement of private companies in water resource monitoring is usually project-based and in many ways linked to government departments objectives. Private companies were included in the study

mainly because they are conducting projects on water resource monitoring and compliance to service the needs of industry and public sector clients. Other government departments were also included in the study because they collaborate with DWS to run the River Health monitoring programme which assesses the status of the streams in the Upper Vaal Water Management Area (WMA), Olifants WMA, Crocodile west WMA. Moreover, they have their own monitoring programmes such as effluent discharge monitoring in the agricultural sector.

These institutions are connected in many ways with regards to water resource monitoring; however most of them work in silos and more often than not duplicate the work of the others due to a lack of communication and various other dynamics. Factors that contribute to the fragmentation of the South African water resource monitoring institutional framework will be discussed in Chapter Four.

3.5 STUDY POPULATION AND SAMPLING PROCEDURE

The Department of Water and Sanitation has employed over 2000 people and it is not possible to interview all of them because of time constraints, it was decided that only certain sections of the DWS would be involved such as Directorate: Water Sector Support and Directorate: Institutional Oversight and within those sections there are a number of roles such as Scientist Manager, Scientist Production, Director, Deputy Director, Engineering Technicians and Environmental Officers that are involved in different aspects of water resource monitoring. For external stakeholders, water resource quality and quantity specialists, research managers and project leaders were chosen for this study as seen on Table 3.1.

Table 3.1 DWS participants Roles and Responsibilities.

Directorate	**Directorate: Planning and Information**	**Directorate: Water Sector Support**	**Directorate: Institutional Management**
Divisions	Sub-Directorate: Water Information Management Division: Information Systems Division: Hydrometry (Boskop)	Sub-Directorate: Water Sector Planning and Support Sub-Directorate: Sector Collaboration	Sub-Directorate: Catchment Management Agencies (CMA) Division: Water Quality Programmes Division: Water Quality (Wilgemooi) Division: Water Quality (Grootdraai/ Blesbok) Division: Water Quality (Rietspruit) Division: Water Quality (Waterval)
Role	To provide efficient and integrated water management	To provide support to water sector operations	To provide institutional establishment, management and support
Responsibilities	The management and assurance of protection of surface and groundwater (Including Acid Mine Drainage (AMD) and River Health	The development of water sector capacity, support of water sector planning, management of intergovernmental	The facilitation of the establishment of Catchment Management Agencies and Provincial Water Institutions and

	Programme (RHP)) and the management of water resource data/ information	relations, support sector sanitation implementation programme	oversight of water institutions
Potential participants	Director and /or Deputy Director Scientific Managers Scientist Production Control Scientific Environmental Officers Environmental Officers Production and Specialized Production Control Engineering Technicians GISc Professionals Control Survey Technicians	Director and /or Deputy Director Assistant Directors Chief Development Expert Community Development Officer	Director and /or Deputy Director Control Environmental Officers Scientist Production Environmental Officers Production and Specialized Production

*Adapted from the Department of Water and Sanitation: Approved Organizational and Structure Operational Integration, May 2014.

The unit of analysis was the DWS national and regional officials as well as external stakeholders involved in water resource monitoring, particularly scientists, engineers, managers and directors. In the DWS national office, 27 representatives were interviewed, as well as 18 DWS regional officials, 14 External Stakeholders and 4 key informants and finally five focus group discussions were conducted between June 2015 and June 2016. The technique used here was expert sampling where respondents were

chosen based on their expertise on the issue being studied. This technique was chosen mainly because experts tend to be more familiar with the subject matter; water resource monitoring and information systems and their opinions are credible. The skills base of the respondents included water resource monitoring data collection, analysis and dissemination, as well as management aspects such as reporting on the state of the water resources.

Table 3.2 External Stakeholders involved in Water Resource Monitoring.

Institution	**Role**	**Potential Participants**
Department of Water and Sanitation (DWS) Water Monitoring Governance Structure Support Staff	Assist in co-ordination and integration of monitoring programmes and develop policies and guidelines to support water monitoring governance.	Director (Information Programmes (IP) Scientific Manager (IP), Scientist Production (IP)
Rand Water	Monitoring the Vaal Catchment for Water Purification and Distribution of potable water throughout Gauteng and other regions.	Water Quality Specialist, Water Quality Advisor
Water Research Commission (WRC)	Reviewing the existing monitoring programmes within the water sector and see how they can be streamlined in order for data need to be in one central place.	Water Resources Research Manager
South African National Botanical Institute (SANBI)	Wetland rehabilitation programme wherein efficiency of the wetland system will be assessed.	Project Leader
Council for Scientific and Industrial Research (CSIR)	Involved in Inkomati Catchment monitoring,	Research Leader

	Department of Water and Sanitation (DWS) drinking water quality monitoring, Eskom-Lethabo Power Station monitoring, ESKOM-Kusile power station monitoring and Randwater audit monitoring.	
Gauteng Department of Agriculture and Rural Development (GDARD)	River Health monitoring programme: Assess the status of the streams; Upper Vaal Water Management Area (WMA), Olifants WMA, Crocodile west WMA	Director Scientific Manager and Scientist Production
UNISA: Leader Water Flagship	Design of monitoring networks that are optimally designed to address rainfall data monitoring for climate change.	Research Leader under Water Flagship
University of Pretoria: Environmental Management	Projects around Water Resource Monitoring and Information Systems	Research Leader
Catchment Management Agencies (CMA's)	Water Resource Management and Planning. Developing strategies for integrated water resources management within the Water Management Areas.	CMA Directors

Source: Based on 4 Key Informant Interviews in South Africa (June 2015 – June 2016).

To get to a total number of 63 interviews, the snowball technique was employed where the first few participants referred the researcher to other potential respondents that could contribute meaningfully to this study. This

type of sampling is a non-probability sampling technique that was used to identify potential subjects where they would be otherwise difficult to locate. Moreover, this technique was chosen because the sample for the study was very limited to a small sub-group of the population.

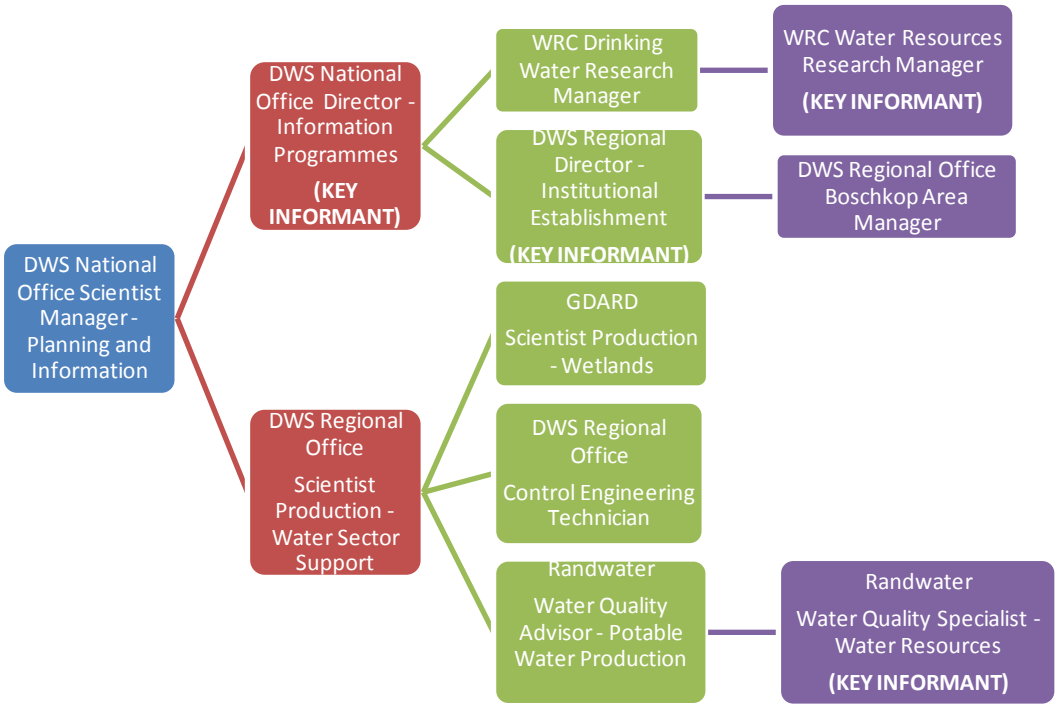

Figure 3.1 Example of snowball technique as applied in this study.

Most of the key informants valuable to the study were identified in this manner. After observing the initial subject, the researcher asked for assistance from the subject to help identify people with similar traits of interest (Bhattacherjee, 2012). The process of snowball sampling (Figure 3.1) is much like asking your subjects to nominate another person with the same trait as your next subject. The researcher then observes the nominated subjects and continues in the same way until obtaining sufficient number of subjects (Bhattacherjee, 2012).

Upon completion of interviews and focus group discussions, the recorded sessions were reviewed in their entirety. Attention was focussed on extracting key evidence and general observations as well as specific

statements of key informants that provided compelling data. The information was brought together in an interview analysis document organized according to the themes derived from the research questions. By reviewing this document in an iterative manner, key observations and interpretations were developed, illustrating common comments and perspectives, and in particular noting the extreme points of view. The data was then synthesized with the data generated from the document review to develop a narrative of the situation. Key themes were drawn out, providing the basis for the conclusions and recommendations of the study. Below is an expansion on the different tools used and what criterion was used to identify the participants.

3.6 DATA COLLECTION TOOLS

Questionnaire surveys

A semi-structured questionnaire survey was selected as one of the data collection tools for this study. It was chosen because it allowed the researcher to look at relationships between and amongst different characteristics, sites and categories (Secor, 2010). Semi-structured questionnaires are appropriate and can be used effectively for investigations like this study where the aim happens to be a probe for attitudes and reasons for certain actions or feelings (Kothari, 2004). A set of questions was sent out to all the respondents with the intention of capturing responses in a standardized manner, and then the responses were combined into a composite scale or index for statistical analysis. Some of the questions were standardised but a lot of them were open ended and afforded the respondent an opportunity for further elaboration and explanation. The questions revolved around trying to understand the institutions mandated to manage water resource monitoring in terms of how they function and fulfil their responsibilities. Other questions were around sustainability of water resource monitoring programmes, climate change, urbanization and their impact on water resources in South Africa.

In addition, there were also questions on water resource monitoring budgets, challenges and legislation.

Interviews

Interviewing is one of the most common means of collecting primary information in qualitative research. The method was selected as an appropriate method to get information from the respondents identified through purposive sampling. According to Kothari (2004), “the interview method of collecting data involves presentation of oral-verbal stimuli and reply in terms of oral-verbal responses”. This requires a person known as the interviewer asking questions generally in a face-to-face contact to the other person or persons. Sometimes the interviewee may also ask certain questions and the interviewer responds to these, but usually the interviewer initiates the interview and collects the information. Personal interviews are usually conducted in semi-structured ways where a predetermined set of questions are used or administered to the interviewee (Kothari, 20004). It is still a formal interview that requires an interview guide and is best used when the researcher will not get another chance to interview the respondent according to Bernard (1988). This method was chosen because it allows for comparability one interview with another, provides a safe basis for generalisation and allows informants the freedom to express their views in their own terms.

The development of the interview guide was initially based on an extensive review of literature guided by the study’s research questions. Later, it was significantly reviewed based on insights generated mainly from informal conversations and the observations made during meetings and workshops. The interviews focussed on specific and contextual water resource monitoring governance issues that affect sustainable water service delivery in all echelons of government. Prominent among the issues covered in the interviews were the possible root causes of institutional disintegration in the water resource monitoring subsector,

dynamics of stakeholder involvement in water resource monitoring e.g. climate change, urbanization, stakeholder engagement, monitoring programme sustainability, organizational challenges/ constraints and roles and responsibilities, regional office, national office and external stakeholder conflicts. The interview guides are included as Appendix A.

A digital recorder was used to record all the interviews which also enabled note taking during the interviews as probe points. It was imperative that interviews were listened to on the same day they were carried out, and significant issues requiring follow-up or clarification noted for possible follow up in subsequent interviews. Interviews with participants overseeing water resource monitoring in South Africa were undertaken concurrently with the implementation of the questionnaire. In addition to the strengths of individual interviews, doing group interviews in a mixed methodology according to Dushku (2000) presents unique opportunities for increasing validity and reliability through triangulation. It also saves on the resources needed by a researcher to cover individuals for information that could otherwise be obtained in a group setting (Dushku, 2000).

The specific strength the interview brought into this study was its potential to enhance reliability and validity of results by allowing collection and analysis of qualitative data on largely open-ended questions covering among others knowledge, perceptions and experiences of the participant about their mandates in water resource monitoring. The questionnaire investigated contextual issues at national and regional level that are believed to have the potential to impact significantly on desired levels of monitoring governance effectiveness.

The sample size (63 respondents) was based on the fact that it is a highly specialized field where exploration of issues depended so much on the respondents' time (one interview took more than 90 minutes), willingness and availability for the interview, and their distinct levels of knowledge and experience with regard to water resource monitoring in South Africa and in

the case study. Some of participants were identified through the document reviews, via internet searches, most via snowballing, whereby one participant recommended others as valuable informants.

Key Informant Interviews

Key informants emerged from all the different sample types/sets (DWS regional and national employees and external stakeholders and control group) as these people were regarded as experts on most of the water resource monitoring dynamics. The interviews with this set of participants sought to extract opinions and or experiences that cover a much wider scope of issues. Because of their vast experience in the water sector, they also tended to know other well-informed people that were useful for this study. The interviews focussed on specific and contextual water resource monitoring governance issues that affect sustainable water service delivery in all echelons of government. Prominent among the issues covered in the interviews were the possible root causes of institutional disintegration in the water resource monitoring subsector, dynamics of stakeholder involvement in water resource monitoring e.g. climate change, urbanization, stakeholder engagement, monitoring programme sustainability, organizational challenges/ constraints and roles and responsibilities, regional office, national office and external stakeholder conflicts. On average one interview was conducted in a day.

Practically, one cannot interview everyone and observe everything; one cannot be at all places at the same time therefore if one wants to use key individuals; it is better to understand the depth of their knowledge based on who they are and develop a relationships with them (Gilchrist and Williams, 1999). The definition of key informants according to Goetz and LeCompte (1990) are “individuals who possess special knowledge, status or communication skills, who are willing to share their knowledge and skills with the researcher, and who have access to perspectives and observations denied the researcher through other means”. Interaction

between researcher and key informant may be formal or informal; however, it is the researcher's responsibility to ensure that such individuals inform the study appropriately. Researchers may request key informants to share relevant documents or use of a combination of interviews and observations, depending on the researchers own capability (Gilchrist and Williams, 1999).

Only four key informant interviews were conducted for this study which mainly targeted management of the water resource subsector, mostly from the national and regional planning and information government branch. Also were external stakeholders in the private sector with many years experience in the South African water sector. This set of people was chosen because of their diverse and specialized knowledge, experience and expertise in water resource monitoring in South Africa and the evolution thereof. In addition to broadly seeking their independent views and opinions about the national policy framework for water resource monitoring, and how it impacted on service delivery, some of the key emerging governance issues were shared with these participants; particularly from the in depth interviews and this assisted in validating those findings. Of particular importance was being able to identify, collect and analyse some of the work that has been done to date to address some of the governance issues and the key informants' contribution thereof so as to extract more information and lessons that could further address the research questions of this study.

Focus Group Discussions

To complement the above methods, the proceedings of the Integrated Regional Water Monitoring Committee quarterly meetings in Kwazulu Natal, Northern Cape, Gauteng and Free State provided insight into current states of water resource monitoring governance, as well as Catchment Forums and Stakeholder workshops with permission from the Director General of the Department of Water and Sanitation. The advantage the researcher had in this instance was that the forums were

already established and it was not necessary to arrange for the same group of people to meet again for a similar purpose as this would have resulted in poor or non-attendance due to time constraints. Also, some of the key informants formed part of the forums and the researcher was invited to the various committee meetings.

A total of five focus group discussions were conducted and at least four participants attended each meeting. Each focus group comprised three to eight participants on average, with 29 per cent men and 71 per cent women. They consisted of technical staff, project managers of various sections in water monitoring, DWS national and regional officials, other government department like Department of Environmental Affairs and Department of Science and Technology, municipalities and DWS external stakeholders i.e. institutions responsible for water resource monitoring like Water Research Commission and Randwater. These meetings were held over a time period of 12 months and provided a large proportion of the information that has been used in this study.

Review and Analysis of Documents

Documents serve a very important function as a data source in qualitative research (Bowen, 2009) because in order to gain insight into the subject at hand and understand the workings of organisations, one needs to identify and critically analyse relevant data (Gibson and Brown, 2009). Document review and analysis involves identifying and utilizing historical data and information to answer a different research question or issue than was intended by those that collected the data or prepared such documents (Schutt, 2011; Gibson and Brown, 2009). Once found, the relevant documents are also useful for understanding the political climate, the journey that led to the development of the current policies and the manner in which government addresses issues regarding water resources.

The DWS library and website provided useful sources of documents for review; however, more documents were identified during the actual

interviews with participants. The documents identified during interviews included journal articles, annual reports and newspaper articles, some of which were authored by the interviewees on the work that has been done to date on water resource monitoring governance. Other sources included the very few MSc and PhD thesis that attempted to address water resource governance issues. These documents were considered key for this study mostly because they serve as a starting point to identify gaps and attempt to address them. The journal articles especially, helped in enhancing the understanding of relationships between key actors in water resource governance, the roles and responsibilities of the actors and the challenges experienced by these actors in playing these roles to support water resource governance.

The review and analysis of policy and guidelines also assisted in the understanding of the relationship between international and national contexts of water resource monitoring, its interpretation and operationalisation in the water legislation, strategies and guidelines and the analysis of contextual limitations that make policies ineffective. In order to understand the national guidelines and laws concerning financial accountability and human resource policies in the water sector, the annual performance plan for the fiscal years 2014/15 to 2016/17 was reviewed along with the Public Finance Management Act, National Water Resource Strategy 1 and 2, National Water Act, Water Services Act, Water Research Act. For ease of reference, a document review and critical analysis checklist was developed, even though it was not followed meticulously, it was intermittently revised to appropriately address the study needs. These documents were very helpful as sources of data for answering some of the study's research questions and they also informed the overall study design, methods and some of the fieldwork decisions.

3.7 DATA ANALYSIS

Data Capture and Storage

For a study of this nature, a good data management strategy (data acquisition, data storage and data analysis) was required as the work involved a lot of travelling and interactions with multiple people including the supervisor, colleagues and interview participants and this implied that data would be scattered and one may lose track of where and why data was stored. For this reason, data management needed to begin before the study and continued through fieldwork up until write up and completion of the thesis. Prior to commencement of fieldwork, folders specifying categories of electronic materials were organised and relevant data files saved in their corresponding folders. Observation notes, newspaper articles and recorded interviews were saved in appropriate folders bearing their dates. This ensured efficiency in locating such data as well as developing and enhancing early data associations. The bulk of this study was of a qualitative nature and the researcher was more of a tool of data collection as Parahoo (2006) states. Even though a recorder was used to record all of the interviews, the notes that were taken during interviews were more as probing clues rather than verbatim capture of data or voices of participants.

Recorded interviews were regularly listened to and vital clues for data analysis and further interviews and discussions noted. With regard to survey data, field survey questionnaires were edited for completeness and clarity of recording. Any issues that were encountered were discussed with the supervisor to establish in particular, if they carried important implications for quality assurance in the data collection and management processes. Further safety and control measures were put in place through backups using an external hard drive and sometimes uploading to a *dropbox* account specifically opened for that purpose. Data summaries from interviews and observations as well as materials downloaded from

the internet were saved with file names that reflected their group or class, sources and dates last saved for those that were continuously updated.

Processing and Analysis of Data

Quality controls were integrated in the overall research design, strategy and methods to ensure effective data collection, reliability and validity of the results. And to improve rigour and reliability of the case study design, method and data triangulation were the approaches used. Processing and analysis of qualitative data started during the fieldwork and continued throughout the writing of this thesis. Listening to audio recordings, transcriptions, editing and storage into microsoft word files was done as more interviews were being undertaken. The data was mixed between statistical and written comments and information from the open ended questions. The capturing of information from the open ended questions assisted in identifying common perceptions and views expressed by participants.

Table 3.3a Microsoft Excel worksheet (Monitoring Organizations in South Africa)

Monitoring Organizations	Count	Percentage %
Local Municipalities	28	20
Catchment Management Agency	7	5
Other Government Departments	21	15
Research Councils	14	10
Industry/Mines	10	7
Water Utilities	6	4
Private Companies	16	11
Department of Water and Sanitation	14	10
Public	9	6

Research Institutions (Universities)	17	12
Total number of citations	**142**	**100**

Table 3.3b Microsoft Excel worksheet (Fulfilment of monitoring responsibility by organizations)

Fulfilment of Monitoring Responsibility	
Respondent	Response Item Yes/No
DWSNO1	Yes
DWSRO1	No
DWSES1	Yes
CONTROL1	No
Total Yes	**57%**
Total No	**43%**

The data was then transferred to Microsoft excel worksheets as seen on **Tables 3.3a** and **3.3b**, for simple frequency distribution and pivot table observation for further editing, summary statistics generated for each variable and transformation performed for some variables before the actual analysis started. Data analysis involved generating descriptive statistics for indicator variables and was displayed using frequency distribution tables and charts. Descriptive statistics focussing on measures of central tendency and dispersion (i.e. mean, median, mode totals, minimum, maximum etc.) were generated for the continuous variables namely: number of years in the water sector, challenges experienced in water resource monitoring, relationship between data management and quality, roles and responsibilities and stakeholder engagement and efficiency of financial management.

The analysis of data generated by the above-mentioned qualitative methods was largely informed by models and approaches suggested by Yin (2003). Among the various techniques or approaches he proposes as suitable for the analysis of data generated in case study designs, *pattern matching* and *explanation building* were found to be very useful and have been applied in the analysis of this study's qualitative data and cross-synthesis with survey data. In the *pattern matching* analytical technique, comparisons were made between the predicted patterns (mainly based on theory) and the emerging and observable patterns or issues from the data (empirical patterns). When collecting case study data, the main idea is to "triangulate" or establish converging lines of evidence to make the findings as robust as possible (Yin, 2003).

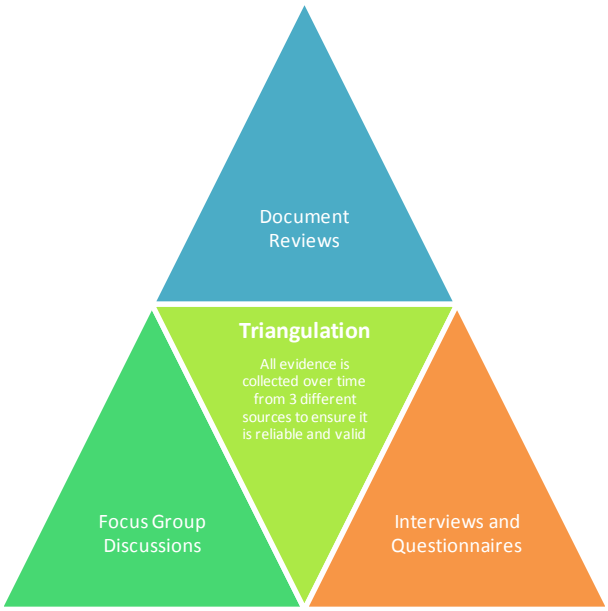

Figure 3.2 Triangulation of evidence. Source: Adapted from Bilash (2009)

The theoretical debates and issues around water resource monitoring governance discussed in great detail in Chapter Two significantly informed the construction of theoretical propositions or suggestions that were tested and contrasted with the findings in order to generate explanations (explanation building). This technique was utilized throughout the fieldwork and data collection process. Theoretical reflections or considerations on

the empirical data continued after fieldwork right up to the thesis writing stage. For conclusions to be acceptable and correct, tables and charts were used to map out and describe relationships (similarities and difference) based on data collected and study specific issues. The patterns that emerged from this exercise were continuously modified to reflect theoretically important propositions against the data (pattern matching).

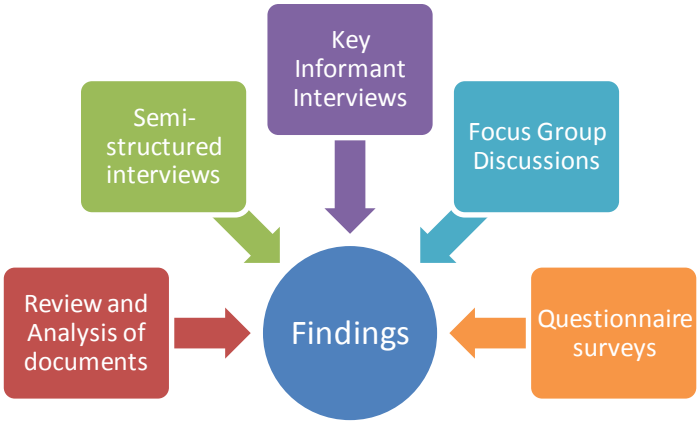

Figure 3.3 Convergence of multiple sources of evidence. Source: Adapted from Yin (2014) p121

Following the principles of theoretical triangulation as stated by Thurmond (2001); pattern matching and explanation building, the main analytical techniques used in the analysis of this qualitative study were applied in a mutually inclusive, integrated and simultaneous manner. During the data analysis stage, triangulation assists in enhancing the confidence in one's findings through convergence of different perspectives or independent approaches (Campbell and Fiske, 1959), mainly based on comparing data to theory, and it is at the point of convergence that reality about a specific research problem or observable fact is understood (Thurmond, 2001) and the level of insight is broadened (Flick, 2011).

3.8 METHODOLOGICAL REFLECTIONS

During fieldwork, the researcher is exposed to a number of biases for example; spatial, project, person and professional biases (Chamber, 1983). One bias that stood out in this study was the person bias and/or elite bias. Due to the specialist nature of the study, influential, expert and well-versed individuals in the water monitoring field were sought out because of years of experience and the networks they have created over the years. The researcher's values were recognized as an influence on the overall research process and were managed and acknowledged by stating those values and applying research standards.

The challenges experienced during fieldwork were that some participants were reluctant to participate in the interviews and preferred to complete the questionnaires at their leisure. The disadvantage here was that, they could not be probed further and there were missed opportunities to observe and possible referral to their colleagues or experts in the field. Some respondents did not have time to complete questionnaires and did not supply required information. Other respondents did not attend interviews despite reminders and requests and ultimately a 100% response rate was not realized even though more than 100 questionnaires were distributed ahead of time and interviews where scheduled ahead of time and ample time was given to respond.

The study would have benefitted from a greater number of participants to provide a more diverse and rich picture of the perspectives on water resource monitoring governance. Nevertheless, within the 12 months of data collection, there were some good insights found useful in informing findings and conclusions for this study. These have been integrated in the analysis of findings on the factors that make it difficult to develop a framework for water resource monitoring presented in Chapter Five. Before the fieldwork could begin, permission had to be sought from the DWS Director General (DG) to interview DWS employees. This was in the

form of a submission which the DG had to sign and approve. The approval of that document took about four months to obtain and had negative impact on the schedule as it delayed all other research activities.

It was imperative during interview and observation introductions, to always emphasize interests as a student of the University of the Witwatersrand without denying the title of co-ordinator of the water resource monitoring forums in Gauteng, Kwazulu Natal and Free State. This was done by clarifying the research objectives and role as an academic researcher as it had the potential to impact on the study both in terms of fieldwork and data interpretation. This worked very well in building a rapport with the DWS national and regional representatives and key informants and confidence for very fruitful discussions and interviews. One of the fears was that participants would not be forthcoming with information as some of the questions required participants to criticize their employer or other co-workers; especially during observations (Integrated Regional Water Monitoring Committee (IRWMC) meetings and stakeholder workshops). This was circumvented by conducting one on one interviews in consenting participant's private office at their place of work, or any other private office or at a location of their choice where the conversation would be private and not be heard.

Interpretation was not only based on theory and perspectives of other researchers, but also personal experiences in interactions with water boards, research institutions, government departments and general water resource management frameworks in South Africa. Different people interpret data differently and personal experiences played a role when analysing qualitative data and this research was no exception. Coming from a physical science background where a fair amount of laboratory work was conducted; it was a challenge to transition into the social world and delve into social issues and articulate them in a rational manner. A considerable amount of time was spent trying to understand social science theory and its basic tenets and how they could be applied in this study.

Most researchers if not all, hope to contribute to current knowledge and design strategies and frameworks that could benefit the study participants directly. Even though it was explained to the participants that their contribution would help improve the water resource monitoring, they still saw the researcher's role to be data mining, it would take long for them to realize the benefits promised and to link it to any research they participated in. Meeting with key informants, formal interviews and discussions, informal discussions not only contributed to the researcher's data collection experience but also helped the researcher to identify opportunities for testing some of the emerging theories. The other dimension this added was enabling the regional employees to see their own potential for improving the water resource monitoring landscape without always looking at DWS national office for answers.

To conclude, the use of different methods (quantitative and qualitative) of data collection was considered to be the plausible choice for this study given the researcher's background in the water sector and the researcher's position within the study. In their nature, mixed methodologies allow one to test theory and make informed decisions so as to maintain credibility of results. However, utilizing mixed methods brings about an enormous amount of data from different sources and this may cause frustration and confusion at the data analysis stage of the study. However the research design and methods allowed for detailed analysis of available literature from policy documents in the public domain and those within the DWS as well as data generated through interviews and observations and this assisted in trying to make sense of the data. Methodological instrumentation was vital in that it allowed the researcher to collect quality data that will inform and answer the research questions referred to in Chapter One. By using interview guides and questionnaire surveys, the researcher was able to engage with, listen and learn from the participants.

[2]CHAPTER FOUR

EMPIRICAL EVIDENCE

4.1 INTRODUCTION

This chapter is dedicated to the presentation of the empirical data that was collected in the field between June 2015 and June 2016. It specifically looks at a number of key aspects of the water resource monitoring framework. The first aspect is an extensive appraisal of existing water resource monitoring policy, legislation and strategies and the idea is to understand the policy and strategy framework which is used to manage water resources. The second aspect is dedicated to engaging with water resource monitoring actors/role-players within the water sector through interviews and focus group discussions. The third aspect is dedicated to understanding the current structures for water resource monitoring and governance in South Africa such as resourcing for the sector (financial and human capital), current governance structures and lastly, the challenges facing water resource monitoring and water resource management as a whole.

4.2 REVIEW OF EXISTING WATER RESOURCE MONITORING POLICY

The first section of this chapter is a document review of water resource monitoring policy in South Africa. It was important to understand and review the policies because policies show that government is doing something about water resource monitoring and management. In view of

[2] Part of this chapter is based on a paper submitted, accepted and published in conference proceedings. Chabalala, S., Simatele, D. (2017) Exploring the role of institutional and policy framework in water resource monitoring and management in a Sub-Saharan African context: A study of the Gauteng province, South Africa. Proceedings of the 6th World Sustainability Forum (WSF 2017), 27-28 January 2017, Cape Town, South Africa.

this, the researcher engages with the following policies; the South African Constitution, White Paper on a National Water Policy for South Africa, National Water Act and National Water Resource Strategy (I and II). The enactment of these pieces of legislation lies with the Department of Water and Sanitation (DWS); mandated to manage water resources of South Africa through water resource monitoring. In order to understand the background to the current legislation on water resource monitoring in South Africa, one needs to understand the national policy context and the interventions made to date to improve the water resource monitoring landscape in South Africa. Moreover; understanding the national policy context of South Africa is important because it enables an understanding of the South African water sector experience.

Reviewing legislature offers a starting point for the researcher to find out what the challenges and opportunities are in the current water resource monitoring framework. The first document we engaged with was the Constitution of South Africa. The Constitution of South Africa (Act 108 of 1996) formed the basis of all the development policies in the country and for the water sector. In reviewing this piece of legislation we discovered Chapter 2, Section 24 in the Bill of Rights which states that;

"Everyone has the right—

(a) To an **environment that is not harmful to their health or wellbeing**; and

(b) To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that—

(i) prevent pollution and ecological degradation;

(ii) promote conservation; and

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development." (Bill of Rights, Chapter 2, Section 4, Page 9)

This was the foundation for further policy and legislative development that resulted in the current policy and legislative management of water resources in South Africa namely; National Water Policy White Paper, National Water Act and National Water Resource Strategy (I and II),as seen on Figure 4.1

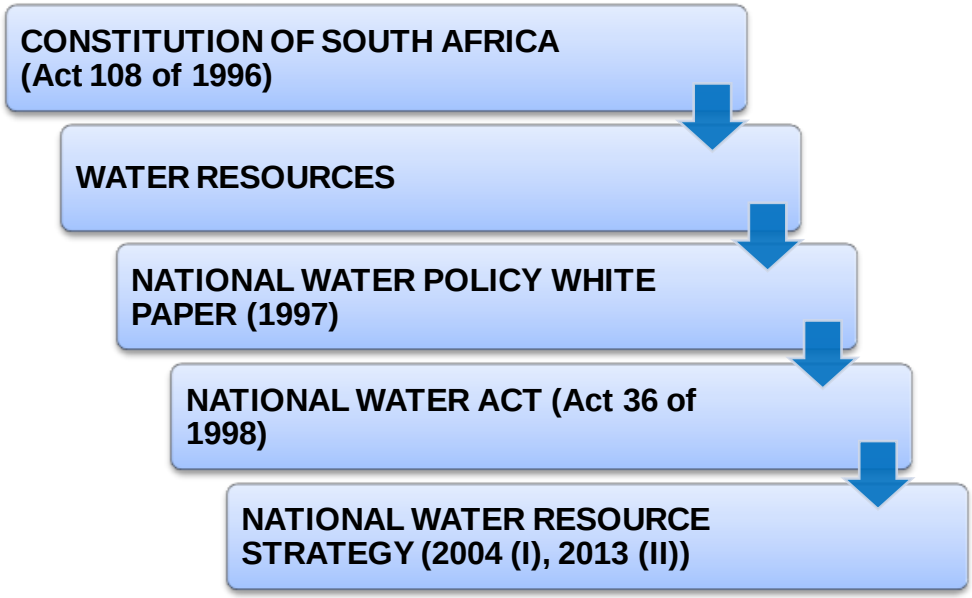

Figure 4.1 Water Resources Management policy and legal framework. Adapted from Marjanovic et al., 2011.

The White Paper on a National Water Policy for South Africa is based on Chapter 2 (Bill of Rights) of the South African Constitution, Section 27 ((1)(b)) and Section 24 () which states that;

"**Everyone has the right to have access to sufficient water**." (Bill of Rights, Constitution of South Africa, Section 27 (1) (b)) - In the context of the reform of the water law, the right to equality requires equitable access by all South Africans to, benefit from the nation's water resources, and an end to discrimination with regards to access to water on the basis of race, class or gender.

"Everyone has the right to an environment that is not harmful to their health or wellbeing." (Bill of Rights, Constitution of South Africa, Section

24 (a)(b)) - This section of the Constitution moves away from the old approach that pitted environmental goals against economic and developmental ones, and requires, instead, that they be integrated.

The purpose of this White Paper is to:

> "provide some historical background regarding access to and the management of water in South Africa;
> explain the current development context in which South Africa finds itself;
> explain the environmental and climatic conditions which affect the availability of water in South Africa;
> put forward certain policy positions, based on the Fundamental Principles;
> outline the proposed institutional framework for water management functions;
> outline the steps which will follow the publication of this White Paper in order to translate the policy into law and action." (National Water Policy, Section A (1.1))"

This implies that the White Paper on a National Water Policy for South Africa was to set out the policy of the Government for the management of both quality and quantity of water resources. It had to reflect the requirements of fairness and equity, values which are cornerstones of South Africa's Constitution and also the limits to the water resources available to the country, primarily because water was mostly used by a dominant group which had privileged access to land and economic power. It was then envisioned that the National Water Bill will be drafted on the basis of this White Paper, to be tabled in Parliament during the course of 1997. This was in response to the need for integrated assessment of water resources to address the often competing human needs and that of environmental sustainability (DWAF, 2008b). It states that water is a "public good" and commits the national government to serve as the public trustee of the country's water resources (DWAF, 2008b). It highlights that

“ongoing monitoring and assessment of the patterns of resource use, and the response of the resource to use, are critical for effective resource management and protection” and that the protection of water resources should be based on sound scientific and technical information.” (DWAF, 2004)

The National Water Act (Act No. 36 of 1998) was then promulgated in 1998 “to provide for fundamental reform of the law relating to water resources; to repeal certain laws; and to provide for matters connected therewith” (NWA (Act No. 36 of 1998)).The objective of the Act is “to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors” - in a sustainable and equitable manner, for the benefit of all persons. The Act provides that the National Government, as the custodian of the nation’s water resources and acting through the Minister of Water and Sanitation, has the power to regulate the use, flow and control of all water in the Republic of South Africa (NWA (Act No. 36 of 1998)).

Pollard and du Toit (2007) having selected the two cornerstones of the Act – ‘sustainability and equity’, suggest that the NWA and related policy documents such as NWRSII provide an enabling environment for managing water resources in complex environments in South Africa. It is important to note that they suggest catchment management strategies are a sustainable and equitable way to achieve Integrated Water Resource Management and must be reviewed every five years. Owing to the fact that the management approaches of the past have failed to deal adequately with the challenges posed by complex and rapidly changing systems which call for integrated approaches such as those embodied in Integrated Water Resource Management (IWRM). (Pollard and du Toit 2007) suggest that any attempt to define and implement viable and effective governance of water resources, as well as rehabilitation

measures, requires understanding that catchments are complex systems showing the aforementioned characteristics.

Under Chapter 14, the National Water Act states that; “Monitoring, recording, assessing and disseminating information on water resources is critically important for achieving the objects of the Act. Part one of this Chapter places a duty on the Minister, as soon as it is practicable to do so, to establish national monitoring systems. The purpose of the systems will be to facilitate the continued and co-ordinated monitoring of various aspects of water resources by collecting relevant information and data, through established procedures and mechanisms, from a variety of sources including organs of state, water management institutions and water users.” If we look at this statement, it is clear that this section provides the legislative framework for sustainable water resource monitoring in South Africa and forms the basis for this study.

Part 1 of Chapter 14 of the National Water Act No. 36 of 1998

“137. Establishment of national monitoring systems

(1) The Minister must establish national monitoring systems on water resources as soon as reasonably practicable.

(2) The systems must provide for the collection of appropriate data and information necessary to assess, among other matters—

(a) the quantity of water in the various water resources;

(b) the quality of water resources;

(c) the use of water resources;

(d) the rehabilitation of water resources;

(e) compliance with resource quality objectives;

(f) the health of aquatic ecosystems; and

(g) atmospheric conditions which may influence water resources."(NWA, Chapter 14, Part 1, Section 137 (1) and (2))

"138. Establishment of mechanisms to co-ordinate monitoring of water resources

The Minister must, after consultation with relevant—

(a) organs of state;

(b) water management; and

(c) existing and potential users of water, establish mechanisms and procedures to co-ordinate the monitoring of water resources." (NWA, Chapter 14, Part 1, Section 138 (a), (b), (c)).

The purpose of the national water monitoring systems will be to facilitate the continued and co-ordinated monitoring of various aspects of water resources by collecting relevant information and data, through established procedures and mechanisms, from a variety of sources including organs of state, water management institutions and water users ((NWA, Chapter 14).

Part two of the National Water Act (Act 36 of 1998) requires that national information systems be established to cover a different aspects of water resources, such as a national register of water use authorizations, or an information systems on quantity and quality of all water resources that will be generally accessible for use by water users and the general public (NWA, Chapter 14, Part 2, Section 139 - 142). While Part three requires that certain information relating to floods, droughts and potential risks be made available to the public for which the Minister of Water and Sanitation may establish early warning systems to anticipate such events (NWA, Chapter 14, Part 3, Section 144 - 145).

According to the above Act, the Department of Water and Sanitation is the leader of the water sector. It currently performs both implementation and regulatory functions. The focus however, is increasingly becoming policy

development, planning, regulation, sector leadership, oversight and monitoring (Marjanovic, 2011). A number of its implementation functions are being transferred to other institutions within the sector for example; catchment management agencies, where the DWS plays a leadership and regulatory role to ensure that government objectives are met.

Ambitious institutional transformation was proposed and mandated in the 1997 National Water Policy and in the National Water Act No. 36 of 1998, and given further concrete articulation in the National Water Resource Strategy of 2004 (IRR, 2008). Implementation of these reforms has been sluggish which in itself has perpetuated problems that existed at the time that the policies were developed and also intensified the problems associated with the management of the water resources and water supply and sanitation. “Uncertainty related to the institutional framework and the status of the reforms has negatively affected water resources management performance and outcomes, staff morale, recruitment and retention, and accountability” (IRR, 2008).

In July 2013, the Minister of Water and Environmental Affairs released the second National Water Resource Strategy (NWRS2), which sets out the vision and core objectives that respond to the priorities set by government in the National Development Plan (NDP) and National Water Act imperatives that support sustainable development for effective water management. The vision is “sustainable, equitable and secure water for a better life and environment for all and the objectives are as follows; water supports development and the elimination of poverty. The strategy recognises that the manner in which water was allocated in the past was unequal and favoured certain sections of the population. The intention, therefore, is to redress past imbalances in the manner in which water was allocated, water contributes to the economy and job creation, and, water is protected, used, developed, conserved, managed and controlled sustainably and equitably (NWRS2, 2013).

In the National Development Plan, one of the elements of a decent standard of living includes water and sanitation. This element like all other elements requires institutional capabilities especially for public agencies to be able to meet their responsibilities to the communities. However, building institutional capability takes time and effort and South Africa is no exception, it will take a long time for the NDP objectives to be achieved. The South African water sector is at a critical crossroads; service delivery is not at the levels that it should be and the continuation of the status quo threatens water security. In light of water scarcity and strong demands by the community for well-functioning water supply and sanitation services, this poses unacceptable economic and socio-political risks for the country (Segal, 2009). It is for this reason that it is deemed important to move towards a sustainable water resource monitoring framework in the South African context. Monitoring systems in relation to water governance reform is an area which is underdeveloped and tends to be neglected by decision makers in the water sector. The integrated approach to water management places further strain on monitoring systems as they involve a shift in mind-set from primarily monitoring hydrological data to data related to water use and policy processes and implementation (OECD, 2013).

To achieve monitoring integration Nomquphu (2007) notes that traditional fields of surface and groundwater quantity and quality will include an increasing focus on the air and land phases of the hydrological cycle and the various human impacts. And ultimately, any new initiatives will necessitate “fresh approaches to appropriate governance for the crosscutting management of information.” Even Coleman et al. (2010), allude to the fact that a framework is required for future water resource analysis in the country based on the challenges facing water resource management by proposing a background focussing on aspects like regulations, institutions, information challenges, and available technical expertise. Pollard et al. (2007) also noted that any framework designed should ensure that both these principles are achieved through an

integrated systems approach instead of one simplistic management action.

In the 6th version of Water for Growth and Development in South Africa Framework (WGDF), the Department of Water and Sanitation seeks to develop a framework and in essence a course of action where it can ensure sufficient water both in the quantitative and qualitative sense for a growing economy. In order to achieve that, water resource sustainability remains the priority. This planning programme is supported by existing legislation and policy but requires continued political support (DWAF, 2009). South African water management policies and legislations provide for inclusive water governance and an array of water management tools that provide for delegation of powers and responsibilities to relevant levels. Nomquphu et al. (2007) note that the National Water Act provides for greater coordination, and various models to achieve this are emerging at local and regional level. Furthermore; various partnerships and an action-learning approach are seen as essential elements of integrating different disciplines, institutions and business processes (Nomquphu et al. 2007). Many of these existing institutions still have interaction complexities in terms of shared water management. The success of the WGDF is heavily dependent on establishment and commissioning of a steadfast institutional framework for water management with clear roles and responsibilities both in terms of water resource management and water services. Moreover, it is important that the elements of this institutional framework be capacitated to fulfil the expectations with regard to their roles and responsibilities (DWAF, 2009).

The water resource protection theme emphasises the need to protect our freshwater ecosystems, which are under threat because of pollution from a myriad of sources. Moreover, climate change is set to alter the environment in future and present new challenges which include; altered rainfall patterns, higher temperatures and increased occurrences of drought and floods (NWRS2, 2013).The NWRS2 is not without its

challenges but it does propose new approaches that ensure a collective and adequate response for the benefit of all people in South Africa. One of the key challenges is to increase the skills and capacity within the water sector for both water resources management and water services. Moreover, regulatory capacity needs to be increased to improve compliance and ensure that standards and license conditions are met as this is an invaluable part of strengthening the current institutional framework and capacity (NWRS2, 2013).

Since the publication of the first National Water Resource Strategy in 2004, new challenges have emerged, and many changes have occurred in the water sector, which required new thinking and innovation. Hence, the strategy aims to focus on areas on these priority areas for the next five years (2013-2018);

I. Achieving equity, including Water Allocation Reform,
II. Water conservation and water demand management,
III. Institutional Establishment and Governance,
IV. Compliance monitoring and enforcement,
V. Planning, infrastructure development and operation and maintenance of water resources infrastructure.

As mentioned above, policy and legal issues within the water sector have hampered implementation of the institutional arrangements and highlighted the need for institutional realignment within the sector. In this publication, DWS aspires to move towards; identifying roles, responsibilities and accountability within the water value chain are better defined, to separate the policy making, implementation and regulatory functions, to rationalize the number of institutions reporting to the Minister and aligned to improve delivery, good governance, economies of scale, financial viability, transparency and accountability; ensuring that the sector has sufficient institutional capacity to achieve its mandate and government outcomes and to improve water resource management and water services

delivery; having an institutional framework for the water sector that is simple, clear and pragmatic (NWRS2, 2013).

It also seeks to address the changes needed to enable water sector institutions to effectively contribute to government's development and transformation objectives. "Clarity and certainty regarding future institutional arrangements in the following five strategic areas is urgently needed in terms of; developing, financing and managing national water infrastructure, managing water resources at the local and catchment level, managing regional water infrastructure and supporting local government in the delivery of water services, managing local water resources infrastructure, supporting resources for poor farmers and transformation of the irrigated agricultural component of the water sector and regulation of the sector." (NWRS2, 2013)

In terms of Chapter 13 of the NWRS 2 (2013), the DWS must; "Develop and implement an integrated national information management plan for the entire water sector that is easily accessible to government institutions and to other users. This plan must include the following; planning and implementing water resource development and water services infrastructure, monitoring for compliance, and monitoring for early warnings to avoid, limit and mitigate risks in water management." (NWRS2, 2013)

The following four policy briefs give a framework to start looking at water resource management issues in South Africa. They also give an indication of what has been done in recent years in terms of plans and proposed frameworks. A number of draft documents were produced by the Department of Water and Sanitation aimed at developing a monitoring governance model for National Water Monitoring in South Africa.

4.2.1 Five Year Water Resource Quality Monitoring Plan

The purpose of the document was to provide necessary direction and the basis for reviewing the current monitoring programmes and designing new programmes. The document describes the status of monitoring in the country as at December 2004 and where the authors would like to be in five years together with critical interventions to achieve the objectives of this plan (DWAF, 2004). In consultation with regional and provincial offices, a Water Resource Quality Monitoring Task Team from the Chief Directorate: Information Management was established to work towards an efficient and effective monitoring service. This was envisaged to stimulate discussion on a way forward because high levels of co-ordination would be required if the objectives are to be achieved. The Policy and Regulation branch of the Department of Water and Sanitation recognized the need to integrate water resource quality monitoring services through harmonizing, monitoring and analysing methods used by different monitoring programmes and institutions.

To date, there are still 11 Departments of Water and Sanitation monitoring programmes and no new programmes have been launched although the existing national programmes have expanded, as water resource management at Water Management Area (WMA) level gains momentum, requiring more detailed status and trends monitoring. Fourteen more monitoring programmes have been identified and the suggested programmes were geared at assessing water and land based impacts on water resources and managing the impact thereof (compliance monitoring) which would be achieved through authorizations, policy changes, rehabilitation etc. where the monitoring will mainly support water resource managements that will be delegated to lower levels, and will, to a large degree, also have to be done by the users themselves (DWAF, 2004). These recommendations have not been implemented to date with the exception of the three CMA's (Catchment Management Agencies) that have been established.

4.2.2 Perspectives on the Framework of Water Resources Monitoring Governance at DWAF

The purpose of this framework drawn up in 2006 was “to coordinate and induce collaboration in the water sector to monitor South Africa’s water resources efficiently and effectively in order to generate the credible information that is necessary to manage, protect and restore our valuable water resources” (Water Resource Information Programmes). The long-term goals were to “strive for methods and data comparability (by standardizing on monitoring design, sampling protocols and analytical methods, data management and data accessibility; ensuring that water resources are accurately, effectively and efficiently assessed and continual reporting on the status of the country’s water resources.”

The framework was developed as a vehicle to facilitate integration, co-ordination and collaboration among water sector partners, government departments involved in the management of hydrological cycle, including DWS units, DWS Regional offices, NGO’s, research institutions, water management institutions, and local government within the context of their own jurisdiction and realities.

It was made to address the following;

I. Water resource condition and reporting,
II. Monitoring and evaluation of programmes,
III. Guidelines and standards for water resource monitoring,
IV. Provide a monitoring coordination structure.

The document was meant to be developed further at a later stage to be used by the NWMC to assess progress against expected outcomes for a particular monitoring programme. Figure 4.2 below shows a link between the IRWMC’s (Integrated Regional Water Monitoring Committee) and the NWMC (National Water Monitoring Committee);

Figure 4.2 Links between IRWMC and NWMC. Adapted from 'Perspectives on framework for Water Resources Monitoring Governance at DWAF'.

Where the key responsibilities of NWMC would be to; support effective and coordinated governance of water resources monitoring, coordinate all relevant water resources monitoring activities of clients and stakeholders, standardise and link the water resources monitoring tasks to support research and technology development and coordination to address gaps and overlaps in the mix of crosscutting programmes.

Where the key responsibilities of IRWMC would be to; collect high quality water-related information in collaboration with water sector institutions and ensure that information is made accessible to public and private institutions, implement a national monitoring and information management plan; establish an integrated water information management system; build

technical expertise needed to collect, analyse the water information and to produce reports for decision-makers in support of the “water footprint” concept.

Where the key responsibilities of the National Technical Sub-committees would be to; develop national monitoring strategies and frameworks that will ensure the application of consistent approaches and methodologies in the collection of data and provision of information. The document was meant to be developed further at a later stage to be used by the NWMC to assess progress against expected outcomes for a particular monitoring programme.

4.2.3 Emerging Frontage of Water Monitoring Governance

In an effort to facilitate coordination and collaboration amongst the range of stakeholders involved in various aspects of water monitoring as well as to enhance synergies between the portfolio of National Water Monitoring Programmes, The Directorate: Information Programmes (D: IP) initiated a process of dialogue which culminated in the establishment of a Monitoring Task Team (MTT). D: IP also produced a number of draft documents aimed at developing a monitoring governance model for National Water Monitoring. The first of these was entitled “*The Emerging Frontage of Water Monitoring Governance*”. This document formed the basis for the decision to establish the MTT by the Water Resources Functional Management Committee (WRFMC) in March, 2006. This was where it was proposed that the NWMC and IRWMC be formed, which would encompass both water services and water resources monitoring needs. It was envisaged that the key benefits of having this committee in place are as follows:

I. Standardization of monitoring design, sampling protocols and analytical methods, data management, and accessibility.
II. To ensure that water resources are accurately, effectively and efficiently assessed.

III. To ensure continuation on the reporting of the status of the country's water resources.
IV. Develop business cases for integrated monitoring programmes to optimise and justify their cost to benefit ratios.
V. Investigate and optimise separate water monitoring programmes within the same discipline (e.g. flow, rainfall and telemetry networks or separate sampling programmes for chemical sampling) with comparable objectives to improve return on investment.
VI. Ensure viable quality assurance in all programmes with effective quality control points, feedback loops and reporting structures.
VII. Identify specific interventions required in the regions, initiate remedial actions and monitor progress.

To date, the formal establishment process of the NWMC is a work in progress and their terms of reference have been approved by the DDG: Planning and Information; and for nine IRWMCs progress has been slow due to the lack of human resources needed to support all nine regions and they are yet to customize the terms of reference to suit their environment.

4.2.4 Institutional Re-alignment Project

In 2010, the DWS initiated an Institutional Reform and Realignment process to revise the institutional framework for the water sector. The purpose of the document was to provide an outline of the emerging models for effective institutions in South Africa that covers both water resources and water services institutions. It identifies the main principles to be considered in making decisions on institutional re-alignment and review the emerging regulatory models from various studies conducted internationally and in South Africa (IRR, 2008). One of the key objectives was to rationalize the number of institutions reporting to the Minister and the department for effective regulation and accountability in the

implementation of the National Water Act and Water Service Act and to reduce complexity of the institutional framework in the water sector.

The vision for institutional framework within the water sector on Figure 4.3 is that;

I. DWS continues to be the sector leader and is responsible for the mandate as defined in the Constitution and the relevant legislation.
II. New proposed institution;
III. An independent Regulation Agency that will ensure effective economic, technical and social regulation as a vital component of the institutional structure required to create efficient and effective water service providers.
IV. Because of the 19 WMAs defined in the NWRS, 19 CMAs were to be established, however, this project proposed a reduction to nine CMAs that will report to the DWS.
V. WMAs' new grouping is based on a logical combination of WMAs based on large drainage areas because water management cannot be done on provincial boundaries.
VI. The Water User Associations (WUA) will also be reduced drastically from the current number to a more manageable number with increased areas of jurisdiction and responsibilities as part of the CMA. They will be regulated by the CMA in their day to day activities.
VII. Water Boards still play a critical role in completing the water value chain as they possess the capacity to support government entities to deliver a service. The Water Board's governance will be shared between DWAF and local government.

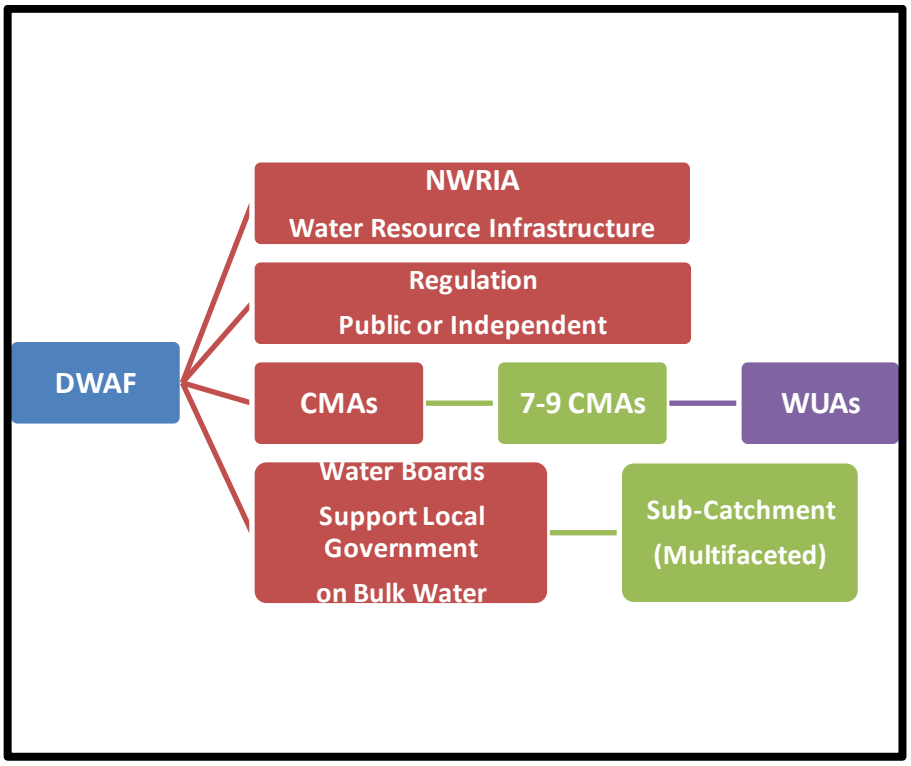

Figure 4.3 Vision of Institutional Framework for Water Resources in South Africa. *Adapted from Institutional re-alignment project (IRR, July 2008).*

The establishment of institutions is necessary for monitoring and protection of South Africa's water resources and in this case the water sector is characterized by complex institutional arrangements. At the national level there are;

- Ministers Water Advisory Committees,
- National Advisory Commission for Monitoring and
- National Water Monitoring Committees.

At the regional level there is an Integrated Regional Water Monitoring Committee and at the local level there are Catchment Management Agencies, Water User Associations and local government.

For each water management area in the country, the NWA envisages that the Minister should establish a catchment management agency. The objective is to ensure that the National Government delegates and

decentralizes water resources management to the catchment level and involves communities in the management of water resources (Salman *et al*., 2006). Section 79 of the NWA states that a CMA can be established either on the initiative of the community or stakeholders in the catchment area or on the Minister's own initiative. As an independent corporate body, the board is either elected by the different water user groups in the area or appointed by the Minister where the composition of the board reflects the interests of the various stakeholders in the CMA. To date only two CMAs out of the proposed nine are fully functional and operational namely; Breede-Overberg and Inkomati Catchment Management Agencies. Vaal and Mvoti Catchment Management Agencies are functioning as proto-CMAs. Additionally, the Minister also has the power to disestablish CMAs (NWA, Section 88).According to the NWA (Section 80), the CMA is responsible for developing and implementing a catchment management strategy, for co-ordinating water use in the catchment area subject to its control, and for advising people on appropriate protection and use of water resources in the area. Section 84 of the NWA goes on to state that; the CMA should be financed through water use charges, funds appropriated by parliament, and funds obtained from any other lawful source.

The NWA provides that WUAs function as cooperative associations of local water users who wish to undertake water-related activities for their mutual benefit (NWA, Section 91 - 98). WUAs are established by the Minister after receiving a proposal from a person or a group interested in establishing a WUA (NWA, Section 92) and like CMAs, the Minister also has the power to disestablish the WUA (NWA, Section 96) and can order a WUA to take certain actions (NWA, Section 95). Being the independent, legal body it is, the membership is determined by the procedures established in its constitution. The WUAs constitution determines its precise functions. In this regard it is important to note that the WUA's primary purpose is to serve the mutual interests of its members, not to operate as a water management agency (Salman et al., 2006).Advisory committees are established to give the Minister advice on specified

aspects of water resource management and use (NWA, Section 99 – 101). The NWA empowers the Minister to establish advisory committees for particular purposes, although these committees are advisory, they can exercise whatever powers have been delegated to them.

4.3 WATER RESOURCE MONITORING SUSTAINABILITY

A question that was important to ask was a question around the concept of sustainability when it comes to monitoring water resources in South Africa. Moreover issues around climate change and urbanization and their effects on water resources were discussed and a number of responses were obtained. Participants were asked to list any changes they had observed in weather patterns and then rank them according to the severity of the challenges that these conditions presented. Table 4.1 shows the results from this exercise.

Table 4.1 Listing and ranking of weather conditions

Type of Weather	**Total no. of Citations**	**%**	**Rank***	**Impacts on water resources**
Drought	84**	40	1	Decreased water quality, Eutrophication, Concentration of pollutants, Crop losses and dying livestock
Floods	68**	32	2	
High Temperatures/Heat	60	28	3	
Total	212	100		

1* = Most Severe; 2 = Second most severe; 3 = Third most severe.

** = Totals calculated from 63 Interviews, 4 key Informants and 5 Focus Group Discussions (consisting of 4, 8 and 11 participants each).

Source: Based on 5 focus groups discussions, 4 key informant interviews and 63 interviews in Gauteng, South Africa (June 2015 - June 2016)

Almost all the responses (citations) identified drought as the most severe weather condition identified as 'dry' with a 'lack of rainfall'. It was the first and most severe weather condition that participants in the Gauteng region observed at 40 per cent. Floods described as high intensity rains, 'flash-floods' and 'wet' was identified second and represented 32 per cent, while high temperatures described as 'heat-wave' was identified third and represented 28 per cent.

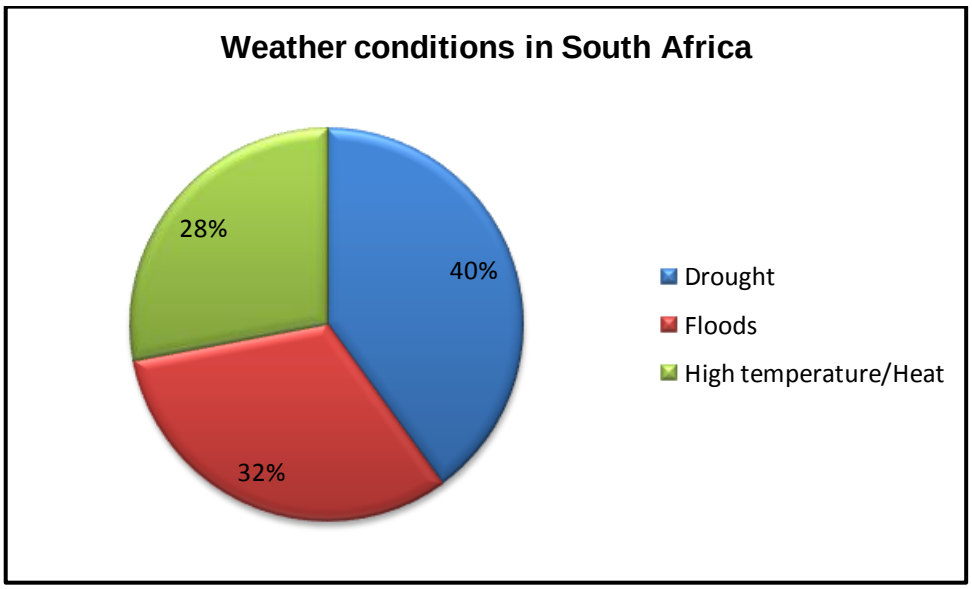

Figure 4.4 Weather conditions in South Africa

Participants were asked if the above weather changes could be attributed to climate change and it was found that 80% of the participants believed that climate change is in fact affecting the quality and quantity of water resources adversely as seen on Table 4.2; and the general consensus was that rainfall patterns and climate in general have been changing over time. From focus group discussions, the participants identified weather events such as **flooding** and **drought** as having a significant impact on water resources of the region.

Table 4.2 Listing of climate change perspectives

Does climate change affect water resources?	Frequency of citations	Total number of citations	Percentage %
Yes	III III III III III III III III III III III III III III III III III III III III III III III III III III III III III III	78	80
No	III III III III III III I	19	20
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

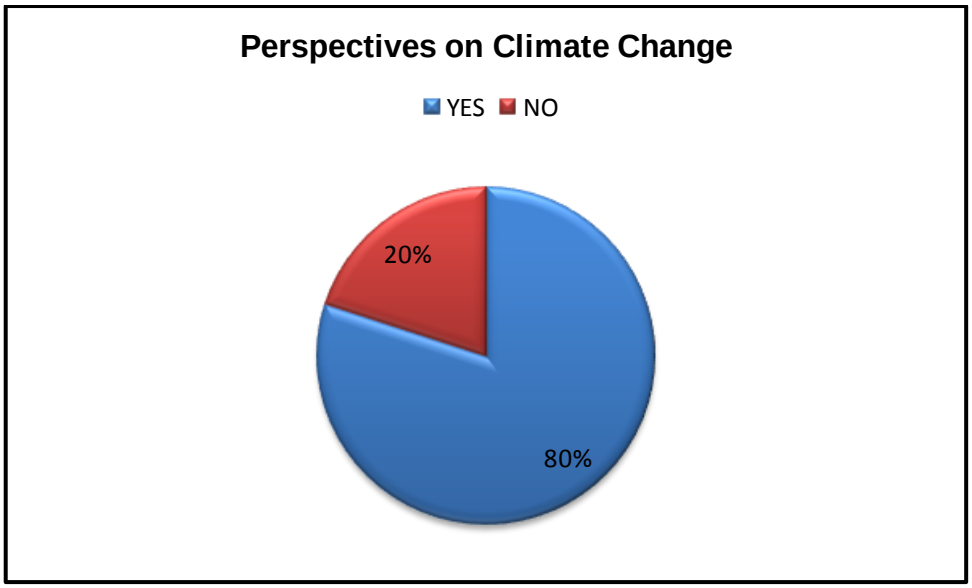

Figure 4.5 Perspectives of respondents on Climate Change. Source: Based on focus group discussions and interviews (June 2015 – June 2016).

No imminent water shortage in Gauteng

KUTULLO MADISHA

WATER and Sanitation Minister Nomvula Mokonyane said Gauteng was not in immediate danger of water shortages despite restrictions being imposed.

"The drought currently affects 173 of the 1628 water supply schemes nationally, serving about 2.7 million households or 8% of the population," Mokonyane said.

There would be strict implementation of drought operating rules at all dams including restrictions, the minister warned.

"The restrictions implemented by the city of Tshwane and Rand Water are part of the result of high weather conditions. I must however confirm that Gauteng faces no imminent risk of a water shortage," she said.

KZN and the Free State have been declared drought disaster areas.

Most of Gauteng's water is supplied by the Vaal and Crocodile West systems. The dam levels are said to be at 84% and pose a manageable short-term water security risk.

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Water levels

- Mpumalanga: 70%, the drought stricken area is primarily located in the South bordering KZN and Swaziland
- Northern Cape located in a semi-desert and depends on climate and depended on underground water. Many people are already using 76% of ground water
- North West average water levels in all dams is 53%
- Western Cape average water level 70%. Low compared to 89% last year at this same time
- Limpopo average water level is 71% with 12 of the 24 dams above 80% and four dams below 50%
- Eastern Cape the average dam level is 78% and most of the key dams are full or close
- Free State average dam level 67%

KZN average dam level 58%. Currently three of 18 large water supply are at risk here

TNA 3/11/2015 B5

Yellow maize peaks as drought fears rise

MARCHING UP: Yellow maize has risen 2.7% to R3040 a ton. PICTURE: REUTERS

TNA 3/11/2015 B 15

PRICES for yellow maize, used mostly for animal feed, scaled their highest peaks this year as drought concerns mounted, further fuelling food price pressures.

Another poor South African maize harvest could have serious implications for Africa's most advanced economy as it will pressure food prices and inflation and so could influence the timing of rate hikes by the central bank, which is in a tightening cycle.

The December contract for yellow maize rose 2.7% on the day to R3040 a ton, its highest this year and bringing its gains so far in the year to 41%.

It is closing in on the record prices of more than R3 400 it reached in March of last year. White maize prices increased 2.6% on the day to R3184 a ton, near its 2015 peaks of more than R3 400 a ton hit in July.

"There is a bit of a panic in our market today, everyone is talking about drought. But even if the rains are late we think they will come," a maize trader said.

The South African Weather Service said last week that an el niño weather system, which was already forecast to bring drought conditions for much of the southern hemisphere's summer, now looks like it will extend into autumn next year.

Dry conditions last year cut South Africa's staple maize crop by a third and the prospect of another drought pushed prices in July for white maize – the staple crop for the region – to near record highs.

Maize farmers intend to plant 2.55 million hectares of the staple grain in the 2016 season, its lowest level since 2011 due to drought. – Reuters

Drought, floods, snow wreak havoc

KUTULLO MADISHA

EXTREME conditions with drought in many parts of the country, flooding in parts of the Cape and snow in the Eastern Cape are wreaking havoc.

Water and Sanitation Minister Nomvula Mokonyane confirmed on Sunday the country was facing drought. The SA Weather Service said Plettenberg Bay had received rainfall of 61mm and 64mm between Sunday and yesterday.

The heavy rains were expected to move to the Eastern Cape coast today.

And while Gauteng, Limpopo and North West especially have recently been in the grip of a heat wave, the highest peaks of the Drakensberg in the Sani Pass region as well as in the Eastern Cape and certain parts of Lesotho have experienced snow.

Experts blame the extreme hot and dry conditions on the el niño effect which according to a Climate Watch report is likely to persist over most parts of the country up to March.

A scientist at the SA Weather Service, Cobus Olivier, said: "These persisting dry conditions may promote a regional or localised drought depending on the state of the existing water stress."

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NEWS SHORTS

Council calls for service payments

THE Thembisile Hani local municipality in Kwaggafontein is appealing to the community to pay for services, particularly water supply and waste collection. Spokesperson Simphiwe Mashiyane said the rural municipality consisted of 64 villages and the majority of residents were not paying for services. She said the municipality was relying on the municipal infrastructure grant as its only income. "The payment of services is a major challenge. The municipality spends about R8m to buy water monthly because water supply is a priority." – France Nyaka

KAMOGELO SEEKOEI

Food security concern as farmers hit panic mode

WITH the drought across the country becoming severe and leading to further water shortages in several areas, farmers are in a panic mode and food security has become a concern.

Grain SA, which is the custodian of everything grain including maize, said it is concerned about the drought because maize production will be affected.

The organisation said it expected the crisis will be more severe in the white maize production areas in the west.

So dire is the situation that the possibilities of yellow maize being used for maize meal (pap) have emerged among some farmers.

The Free State produces 34% of maize in the country while 32% is produced in the North West, 24% in Mpumalanga and 3% in KwaZulu-Natal.

Grain SA said the production areas in Mpumalanga and the Free State where the majority of the yellow maize is produced, desperately needed follow-up rain.

A farmer from Ventersburg yesterday told The New Age they were struggling to keep up production due to a shortage of water. "The lack of rain is really a concern to us because production is already low and because of the drought, it is hard to see how we will increase production.

"Imports will work but at some point it will become more costly," the farmer said.

The biggest concern for farmers is that the intervention from the government, is insufficient for drought relief.

On Sunday Water and Sanitation Minister Nomvula Mokonyane said the country was facing a severe water crisis and the department might have to reduce water supplies if the drought affecting large parts of the country, continues.

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Figure 4.6 Articles on drought, floods and water shortages in South Africa. Source: The New Age Newspaper, November 2015.

One participant for example who is based in Gauteng region of the DWS pointed out that;

> "In the near future, climate change will have a great impact on water resources in South Africa especially in terms of flooding and decrease in water quality, moreover the frequency and intensity of extreme events have become more severe" (Pers. Comm., 2015b).

This view was supported by another participant who is based in a different organization in the water sector who stated that;

> "Climate change is in fact having a negative impact on the country in the form of the drought experienced since 2015, while the drought can be identified as an impact of climate change; the challenge is in quantifying this impact." (Pers. Comm., 2015f)

What we see in this response is the idea about whether data collected through different monitoring programmes can be used to monitor climate change, however another participant was of the view that;

> "One cannot conclude that climate change is the driver of certain weather patterns, therefore we need **monitoring networks** that are optimally designed to address these kinds of issues, especially rainfall monitoring." (Pers. Comm., 2015f)

Another respondent, a researcher from the University Of South Africa (UNISA) mentioned that;

> "Because of South Africa's high rainfall variability for example; large distribution in space of an area across the country, areas with very high rainfall, areas with very low rainfall, it is difficult to identify small deviations and one would need 20 to 30 year records and that data is not available. The rainfall monitoring data for example dates back only seven years." (Pers. Comm., 2015k)

We identified a lot of similar views and it was interesting to understand why that was the case. When we look at the scenarios created here, the main issues drawn out are crop losses and dying livestock which threaten food security in the country, concentration of pollutants in river systems, declining dam levels as a result of drought. Moreover, it was discovered that current monitoring data cannot be used to monitor climate change as there are gaps in data and we cannot confidently say that water resources are affected by climate change A key informant further reiterated that;

> "In South Africa we are unable to attribute any of these variabilities to climate change to any degree of confidence because we are not consistently and continuously monitoring. We haven't monitored enough to make an accurate prediction/conclusion. Yes, there are reports in terms of increased level of carbon dioxide in the atmosphere and how it affects our hydrological cycle; however we

> cannot evaluate the impact. And what we call climate change could just be natural cycles of change. We don't have enough data." (Pers. Comm., 2015k).

It is clear from the participants' views that water resource monitoring is fundamental for identifying possible risks in terms of droughts and floods and to assess the impact of climate change. The discussions show that current monitoring networks are failing to supply information needed to ascertain whether the changes are due to climate change. However, some of the views expressed by participants above seem to suggest that climate change is having major impacts on the water resources of South Africa; the issue centred around uncertainty whether the changes in weather patterns was due to climate change or climate variation over a period of time. Also, it would appear that the concepts of climate variability and climate change are used interchangeably by some of the participants. There was a perception among the participants that human beings are to blame for these changes in climatic conditions and frequency in weather related events. Overall the participants perceived climate change to be a negative result of economic development in the country.

Another important aspect that the researcher considered was the need to have an understanding of how the participants understood the drivers of urbanization and the changes that they experienced. An environmental officer from Gauteng regional office mentioned that;

> "Urbanisation increases the cost of transportation of water to different areas and the cost of large storage facilities in those areas. Moreover, increase in numbers in the urban centres puts a strain on available water resources" (Pers. Comm. 2015m)

As seen on Table 4.3, increased pollution was ranked first as an impact of urbanization, statistically represented at 52 per cent; high water demand ranked second and floods, loss of biodiversity and illegal water connections was ranked third.

Table 4.3 Listing and ranking of urbanization impacts

Urbanization Impacts	Frequency of citations	Total number of citations	Percentage %	Ranking*
Increased pollution	III III III III III III III III III III III III III III III III III III I	55	52	1
High water demand	III III III III III III III III I	25	24	2
Floods	III III III	9	9	3
Loss of biodiversity	III III II	8	8	3
Illegal water connections	III III I	7	7	3
Total		104	100	3

*1 = Most cited; 2 = Second most cited, 3 = Third Most cited. Source: Based on 5 focus group discussions and63 interviews in South Africa (June 2015 – June 2016)

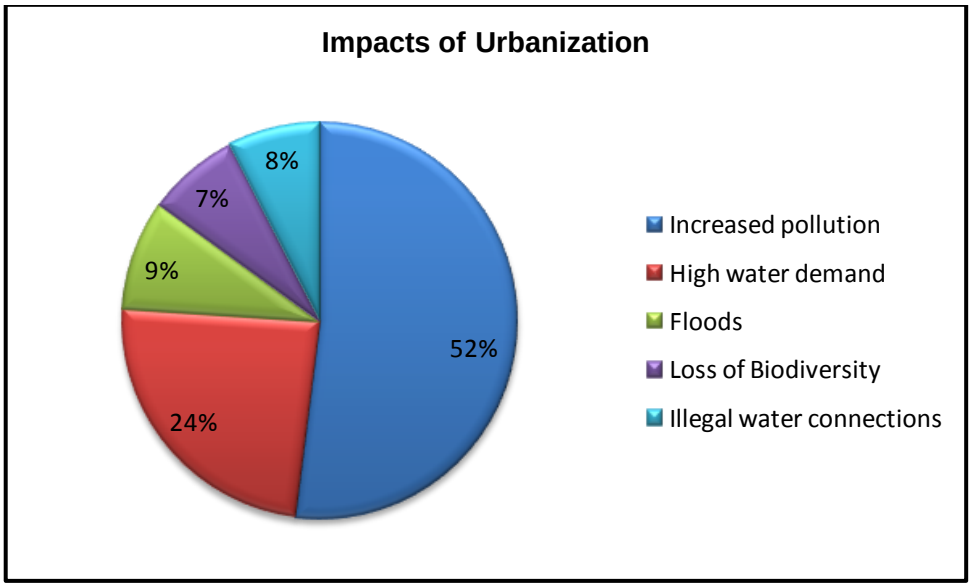

Figure 4.7 Impacts of Urbanization. Source: Based on 63 interviews and 5 focus group discussions (June 2015 – June 2016).

It is suggested in Figure 4.7 that from a total of 108 citations by 97 participants, 52 per cent identified increased pollution as the most important impacts of urbanization which also has other compounding effects such as high water treatment costs as a result of declining water quality and public health issues. This view was supported by one of the Production Managers from Rand Water stating that;

> "Pollution from sewage (improper solid waste management), acid mine drainage and industrial waste, illegal abstractions are a major threat on Gauteng water resources and it's costing more to purify it." (Pers. Comm. 2015d).

One technical manager for example who is based at AECOM spoke about the high water demand in the country and pointed out that;

> "Our waste water treatment plants are not coping, there is a high hydraulic load from the burgeoning population and the plants were not designed for the current volumes. This causes the wastewater treatment plants to be inefficient and the waste ends up in water resources" (Pers. Comm. 2015d).

The views expressed by the participants above seem to suggest the need for new improvements on the current infrastructure to augment capacity as the situation becomes more and more unmanageable. During interviews and focus group discussions; floods, illegal connections and loss of biodiversity were ranked as the third most important and statistically represented at nine, eight and seven per cent respectively. A hydrologist from the DWS national office in Gauteng was of the view that;

> "A rise in urban population impacts runoff on impermeable surfaces and eventual silting up of river systems due to changes in storm hydrology. Also the concrete buildings affect runoff, the extent of infiltration of water into groundwater systems is low, as a result it leads to flash floods for example in Diepsloot in Johannesburg" (Pers. Comm. 2015c)

In addition, illegal abstractions and connections and loss of biodiversity were said to stem from the mushrooming of informal urban settlements and therefore putting strain on available water resources as one of the Gauteng regional environmental officers alluded to by stating that;.

> "Urbanisation impacts on biodiversity because of the destruction of critical habitat." (Pers. Comm. 2015b)

Most of the participants share a common view that urbanization is a negative result of economic development in the country and impacts heavily on the water resources in the country. Overall, the above observations show that monitoring programmes in South Africa are not operating as they should, primarily because we do not have data and/or information to enable prediction of changes in weather patterns and therefore cannot plan for these changes. In view of this, the researcher questioned the sustainability of the current monitoring programmes in South Africa and when discussed, a number of responses were obtained as outlined in Table 4.4 below.

Table 4.4 Listing of monitoring programmes sustainability perspectives

Are monitoring programmes sustainable?	**Frequency of citations**	**Total number of citations**	**Percentage %**
Yes	III III III III III III III I	22	23
No	III III III III III III III III III III III III III III III III III III III III III III III III III	75	77
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

Figure 4.8 shows that 77 per cent of respondents claimed that the current monitoring programmes in the Gauteng region are not sustainable or are not sustainably conducted. A key informant from the DWS pointed out that;

> "The monitoring programmes run by the Department of Water and Sanitation (DWS) may not be sustainable due to challenges such as lack of capacity, funding and long procurement processes." (Pers. Comm. 2015f).

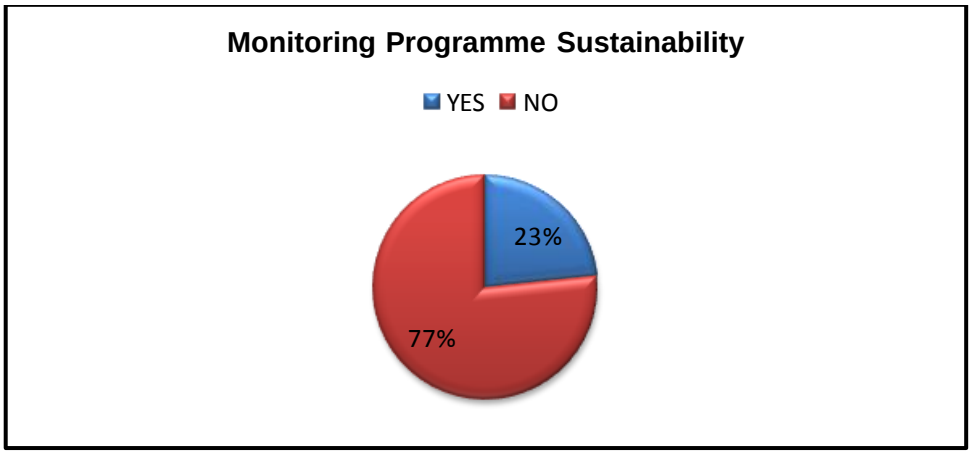

Figure 4.8 Perceptions of water resource monitoring programme sustainability. Source: Based on 63 interviews and 5 focus group discussions (June 2015 – June 2016)

This view was supported by another participant based in the same organization who is also of the view that;

> "DWS Monitoring is mainly done by private consultants on behalf of government entities who are not willing to share their results with other organisations because there is money involved and somebody has to pay for the service. For example ARC and SAWS requires DWS to pay for some critical weather data required for DWS processes. There is an MOU in place for data sharing but it is not implemented. Lack of funding makes the whole process unsustainable. Even more worrying is that the utilization of funds is a problem and getting bogged down in red tape. Unless there is good planning in place we cannot talk about sustainability." (Pers. Comm. 2015j)

A technical manager from the Northern Cape DWS regional office had a different view in terms of monitoring programme sustainability. He stated that;

> "To a certain extent they are sustainable but there is still a shortage of skills in terms of human resources and funds. It's difficult to

> convince top management for investment into monitoring network. We need more studies showing the value of monitoring networks, maybe they would change their perspectives." (Pers. Comm. 2015i)

This view was supported by 23 per cent of the study participants. One DWS national official echoed the same sentiment that;

> "Yes they are sustainable, it's just finances disturb the trends and laboratory contracts cause hiccups. We are working with communities and schools, helping children understand the importance of water monitoring for the future and in that way, we ensure sustainability of monitoring programmes in those communities residing around water resources and building social responsibility within the communities." (Pers. Comm. 2015b).

There are differing viewpoints when it comes to monitoring sustainability, however, one mutual theme we see here is the issue of financial resources and the lack thereof. During focus group discussions it was acknowledged that if financial resources are not allocated for water resource monitoring, water resource management cannot be realized and ultimately no decisions, plans or strategies can be made with regard to water resources.

Further in-depth discussions with different focus groups revealed similar sentiments in that infrastructure is well designed for water resource monitoring especially the bulk water transfer schemes, however it may not be adequate for the growing population outstripping the development cycle. Most participants seemed to view sustainability as a function of having human and economic investment in order to produce monitoring data over a long period of time for management of water resources. It would seem that a shortage of skills or competent human resources and lack of funding are the biggest reasons for unsustainable monitoring programmes.

In view of the above sentiments, another question that was important to ask was around other type of challenges experienced that hinder sustainable water resource monitoring and when discussed a number of responses were obtained. The challenges were grouped into social, environmental and economic challenges and this is illustrated on Table 4.5.

Table 4.5 Listing and ranking of sustainability challenges in South Africa

Sustainability Challenges	Frequency of challenge citations by participants	Total no. challenge citations	%	Rank
Social	IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII I	64	40	1
Economic	IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII I	58	36	2
Environmental	IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII II	38	24	3
Total		160	100	

Source: Based on 63 face to face interviews and 5 focus group discussions in South Africa.

In a total of 160 citations by 97 participants, 40 per cent identified social issues such as the need for training, shortage of skills and a lack of communication among stakeholders. The most cited social challenge was the DWS's lack of a retention strategy for staff. As employees leave the department through retirement, institutional memory is lost. In the same way as better opportunities arise outside the department, employees will leave. And the monitoring field is not inviting because the conditions under which they work are very strenuous and dangerous, especially if there are floods, i.e. logistics.

A technician based in the DWS at national office stated that;

> “There are currently too few technicians collecting data. We are currently using Graduate Trainees to do the work but they are on contract and will be moved elsewhere eventually. And we have to find new people who will need to be trained which costs money again. The way we are going about things is not sustainable.” (Pers. Comm. 2015d).

The issue of staff migration was discussed during the focus group discussions and a manager in the Water Information Management section of the DWS mentioned that;

> “There needs to be a standardised operational procedure in place to assist during massive movement of staff or officials from one job to the other. Skills transfer between public and private sector and within public sector will assist in the sustainability of water resources monitoring.” (Pers. Comm. 2015k).

Other participants alluded to the fact that even if staff are trained to do their jobs, the risk of them searching for better opportunities remains, so it is a constant battle to keep training new people over and over again just to lose their skills to other government departments or private sectors. Also from a social perspective, the issue of politics within government and its stakeholders plays a major role on whether monitoring programmes will be sustainable or not. Every new administration brings new perspectives on priorities and funds thereof and if monitoring is not seen as an integral part of managing water resources, the result is disastrous as many participants have alluded to. Another social aspect that came up was theft and vandalism. It was mentioned as one of the biggest challenges the monitoring fraternity is facing; as one respondent in the Kwazulu Natal regional office alluded;

> “We have a big problem in the field, people are stealing and vandalising monitoring equipment, it is becoming more costly as

> they now need replacing at a faster rate and we cannot keep up." (Pers. Comm. 2015b).

Lastly, accessibility to monitoring points was also mentioned by some participants during focus group discussions as one of the social challenges in water resource monitoring;

> "Our monitoring network points are often remote and inaccessible for examples; boreholes on farms which presents another issue of safety" (Pers. Comm. 2015g).

A key informant from the Water Research Commission brought up a different perspective in addition to the existing challenges. He spoke of poor stakeholder engagement as one of the reasons some monitoring points cannot be accessed in addition to the Memorandums of Understanding between government departments and private sector not being adhered to or being outdated, which in turn leaves nobody to account (Pers. Comm., 2015k).

Economic challenges were identified second and statistically represented at 36 per cent as seen in Figure 4.9. One of the key informants based in the Free State regional office stated that;

> "There needs to be financial investment in water resource monitoring programmes for hydrometrical instrumentation. Weirs are very expensive; to build, one costs a lot of money in instrumentation more than R40, 000.00 for some individual instruments and we simply cannot afford some of them." (Pers. Comm. 2015i).

This view was further reiterated by a scientist based in Northern Cape regional office who is also of the view that Supply Chain control measures that have been put in place to control government expenditure are actually becoming so cumbersome and restrictive that no monitoring work can be done (Pers. Comm., 2015s). This view was also supported by an

environmental consultant in the private sector who is also of the opinion that;

> "The sustainability of any monitoring programme is a function of the investment into it, well firstly is a function of understanding the importance of monitoring, why do we have to monitor? Once people understand that, one would invest heavily into sustaining that monitoring system." (Pers. Comm. 2015k)

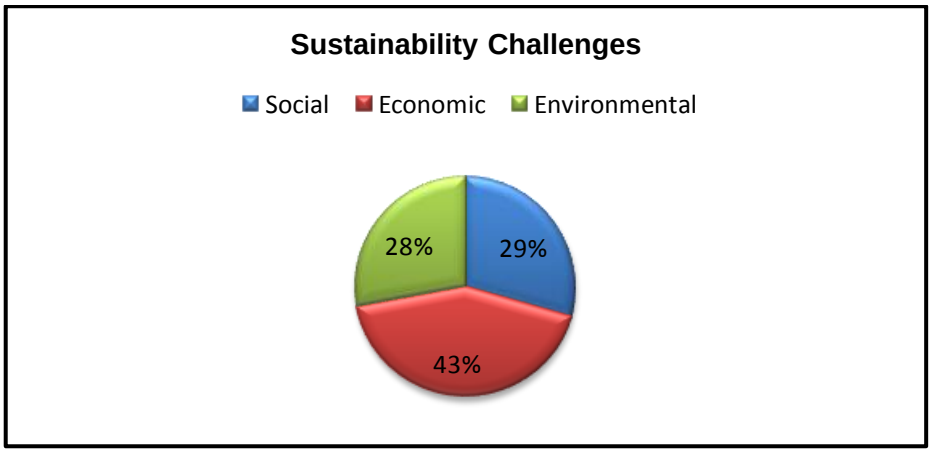

Figure 4.9 Sustainability Challenges. Source: Based on 63 interviews and 5 focus group discussion (June 2015 – June 2016).

The environmental component was identified as the third most important, statistically represented at 24 per cent. A DWS national official pointed out that research must be conducted to understand the impact of fracking, methane extraction and underground coal gasification has on water resources and make plans to mitigate that. (Pers. Comm. 2015l)

The list of phrases on Table 4.6 below also assisted the researcher in capturing the responses on water resource monitoring sustainability according to social, environmental and economical challenges.

Table 4.6 Listing of phrases attributed to sustainability

Sustainability Challenges	Phrases
Social	"need training" "too few technicians" "better opportunity" "data sharing among stakeholders" "vandalism" retention of staff" "accessibility to boreholes on farms" "shortage of skills" "population growth" "community and schools" "filling of posts" "public sentiment" "shared mutual responsibility" "political will and trust" "skills transfer" "lack of communication" "accountability"
Economic	"lack of funding" "developing economy" investment into monitoring network" "economic climate" "financial investment" developing economy" "resources allocated for monitoring" "budget" "restrictive supply chain management procedures" "cutting of funds" "share the cost for monitoring"
Environmental	"global warming" "pollution" "emerging contaminants" "floods" "drought" "health of the resource" "fracking" "carbon storage" "acid mine drainage" "methane extraction"

Source: Based on 63 face to face interviews and 5 focus group discussions in South Africa.

Interestingly, participants cited environmental sustainability or phrases relating to environmental sustainability the least. Respondents were concerned with the fact that global warming, pollution, floods and drought etc. are having a mostly negative effect on water resources, and if those water resources are not monitored, the damage cannot be assessed and therefore deterioration cannot be curbed.

The key findings under this theme were that the change in weather patterns and deterioration of water resources cannot be attributed to climate change as there is no monitoring information to substantiate the claims. However, participants indicated that urbanization does indeed

decrease water quality and quantity through pollution, high water demands, flooding, loss of biodiversity and illegal water connections. When sustainability of the current monitoring programmes was brought into question, most of the participants cited that due to social challenges such as skills shortages and economic challenges such as lack of funding for replacement of aging infrastructure and actual monitoring work and equipment, sustainability of monitoring programmes might never be a reality in South Africa.

In view of all the above, it follows that monitoring programmes are indeed a tool for sustainable management of water resources, however, the monitoring programmes are not being utilized to their full potential because of governance challenges in the monitoring system. This is further compounded by the challenges experienced due to changing the water resource landscape caused by urbanization and perceived climate change that makes it difficult to manage in a sustainable manner.

4.4 WATER RESOURCE MONITORING GOVERNANCE

This section seeks to reassess the respondents' understanding of the legislative framework for water resource monitoring, as well as assess if the role-players are fulfilling their water resource monitoring responsibilities as stipulated in policy documents reviewed in Section 4.1. Lastly, this section focuses on water sector leadership and regulation.

As stated above, this section begins by exploring the different perceptions on legislation in Gauteng region because it was important to have broader understanding of whether the participants involved in water resource monitoring were aware of the legislation that mandates their functions. To achieve this, participants were asked to list and rank the legislation they knew and understood. Table 4.7 shows the results from this exercise.

Table 4.7 Listing and ranking of legislation supporting water resource monitoring in South Africa

Category	Frequency of citations by participants	Total no. citations	Percent %	Rank
National Water Act	III III III III III III III III III III III III III III III III III III III III III III III III III III III III I	64	42	1
National Water Resource Strategy (I and II)	III III III III III III III III III I	28	18	2
Water Services Act	III III III III III III III III II	26	17	2
National Environmental Management Act	III III III III III III II	20	13	3
Municipal By-Laws/ Local Government Act	III III III III III I	16	10	3
Total		154	100	

Source: Based on 63 face to face interviews and 5 focus group discussions in South Africa (June 2015 – June 2016)

It is suggested in Table 4.7 that from a total of 154 citations by 97 participants, 42 per cent identified the National Water Act as the most important piece of legislation in water resource monitoring as quoted below by a DWS national office manager;

> "The Constitution, the National Water Act and the National Water Resource Strategy I and II are the policies that guide the work we do and together they are the legislative instruments available for water monitoring and Chapter 14 of the Act tells us what must be

done and how it must be done and by whom." (Pers. Comm., 2015c)

Followed by the National Water Resource Strategy (I and II) and Water Services Act statistically represented at 18 per cent and 17 per cent respectively as the second most important piece of legislation. Furthermore, Environmental Management Act and Municipal By-Laws/ Local Government Acts were identified by 13 per cent and 10 per cent of the participants respectively to be the third most important pieces of legislation as seen in the bar graph below on Figure 4.10.

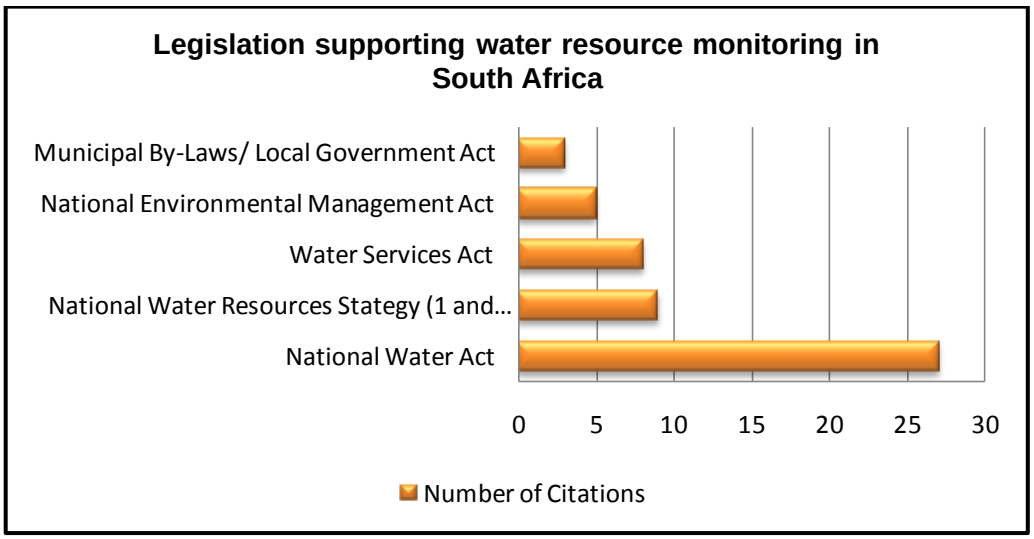

Figure 4.10 Legislation supporting water resources monitoring in South Africa.

Once the perceptions on the legislative framework for water resource monitoring were determined, it was important to understand the types of water resource monitoring institutions in South Africa mandated to monitor water resources as prescribed in the National Water Act (Act 36 of 1998). In other words; the researcher needed to have a detailed understanding of which organizations the participants thought were responsible for water resource monitoring. To achieve this, participants were asked to list the different organizations that conduct monitoring in South Africa. Table 4.8 and Figure 4.11 show the results from this exercise.

Table 4.8 Monitoring Organizations in South Africa.

Monitoring Organizations	Frequency of citations by participants	Total no. citations	Percentage
Research Councils	III III III III III III III III III III I	34	23
Other Government Departments	III III III III III III III II	23	16
Water Utilities	III III III III III III II	20	14
Local Municipalities	III III III III III II	17	12
Private Companies	III III III III II	17	12
Industry/Mines	III III III II	11	7
Catchment Management Agency	III III III I	10	7
Department of Water and Sanitation	III III I	7	5
Research Institutions (Universities)	III III	6	4
Total number of citations		145	100

Source: Based on 63 face to face interviews and 5 focus group discussions in Gauteng, South Africa. (June 2015 – June 2016)

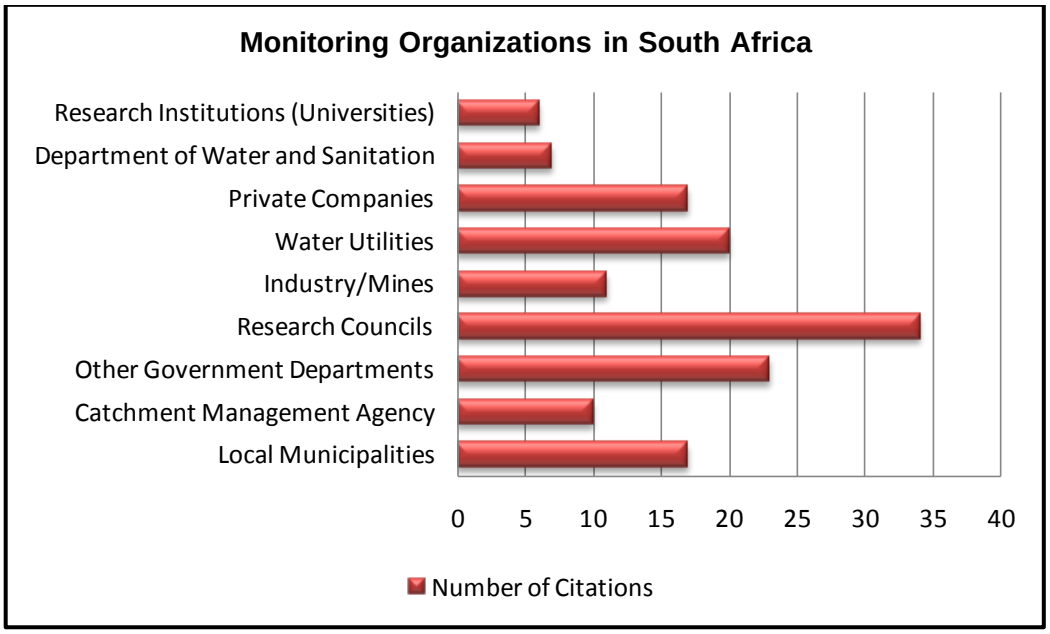

Figure 4.11 Monitoring organizations in South Africa.

Further in-depth discussions with different focus groups revealed that certain institutions monitored particular sites and variables. For example;

> "SAWS collect rainfall data...and ARC collects rainfall data and temperature data....." (FGD 3, June 2015)

> "CSIR monitors catchments and impacts of climate change....." (FGD 4, June 2015

> "SAEON and municipalities monitors groundwater quantity and quality....." (FGD 2, June 2015)

> "Department of Education encourages schools and communities next to streams to volunteer to do mini-SASS, encouraging the community to be passionate about water quality....." (FGD 1, June 2015)

> "Eskom is jointly managing water resources with DWS for generation of hydroelectricity. Moreover Industries are compelled to monitor because of their license requirements." (FGD 3, June 2015)

"Water boards like Rand Water, monitor Vaal river basin because they have a vested interest as they need to purify water to a certain standard." (FGD 5, June 2015)

"CMAs should monitor the catchment in terms of water quality and quantity monitoring and bio-monitoring, toxicity monitoring, microbial monitoring and chemical monitoring but DWS is doing that work at the moment." (FGD 2, June 2015)

It was also important to understand interactions between water resource monitoring institutions and to what extent the policies described in Section 4.1 are being implemented and when discussed a number of responses were obtained and the respondents were of the view that 57 per cent of the institutions are fulfilling their monitoring responsibilities. Table 4.9 shows the results from this exercise.

Table 4.9 Listing of institutions fulfilling their monitoring responsibilities

Are institutions fulfilling monitoring responsibilities?	Frequency of citations	Total number of citations	Percentage %
Yes	III III III III III III III III III III III III III III III III III III I	55	57
No	III III III III III III III III III III	29	30
Not Sure	III III III III I	13	13
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

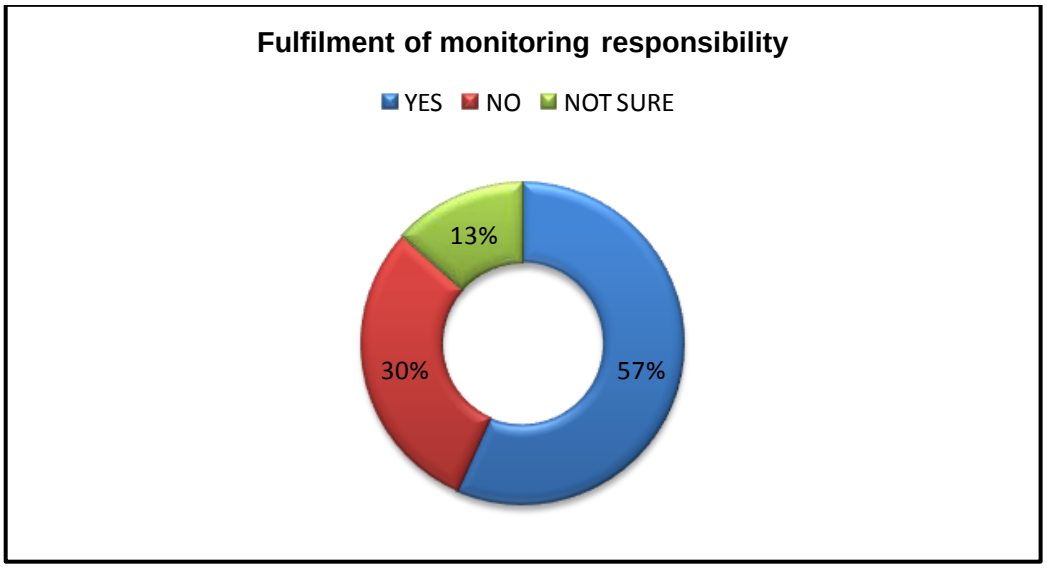

Figure 4.12 Fulfilment of monitoring responsibility.

During focus group discussions most respondents acknowledged that monitoring water resources to meet the demands of the environment, economy and human needs and compliance with legislation is an enormous responsibility. During an interview with a scientist based in the North West regional office of the DWS, the following statement was recorded;

> "Institutions have different and special responsibilities. It is difficult to determine if these institutions have a shared understanding because efforts are often duplicated due to complexity of monitoring activities. Water boards and other private institutions are fulfilling their roles because they need to know the quality of the water so that they treat it to the required standard and water use license requirements compels them to monitor their effluent and discharge. Moreover, DWS external stakeholders are usually on track but government institutions are not." (Pers. Comm. 2015a)

Thirty per cent of the participants cited that institutions mandated to monitor water resources were not fulfilling their responsibilities. Interestingly, the views of participants revolved around municipalities and

their failure to monitor the water resources within their jurisdiction. A key informant based in an environmental consulting company pointed out that;

> "Municipalities on the other hand are not doing their jobs well and their plants are not functional, overall running of municipalities not in the good space." (Pers. Comm., 2015w).

Interestingly, apart from views of the participants on municipalities not fulfilling their water resources monitoring role, there was a perception that DWS is not effective currently, as there are no contracts in place with accredited laboratories. A representative from the Resource Quality Information Service (RQIS) based in Gauteng mentioned that;

> "DWS does not have a contract in place for two years now.....compared to Water Boards that have run their own accredited laboratories.....and regions are not fulfilling their role because of a lack of funding and human capacity in maintaining stations. To have a monitoring network is expensive; DWS could build better relationships with other organizations and share data." (Pers. Comm., 2015c).

The purpose of most of the monitoring programmes is for water resource quality and quantity status, trends and compliance monitoring as one respondent based in the Gauteng regional office alluded to by stating that;

> "We are monitoring for state of water resource reporting and compliance on a monthly basis.....where there are mines, we sample for cyanide, heavy metals and uranium for example, in agricultural sector we sample for ammonia and associated chemicals and in industry we monitor for organics that pollute our water resources in the catchment." In terms of licensing we have to know the quality of that water in order to manage and decide on actions to take." (Pers. Comm., 2015e)

Only a small percentage of respondents (13 per cent) could not comment as they were not sure whether all the delegated institutions were fulfilling their role in water resource monitoring.

In addition to the above responses, one of the key things that the study was looking into was the perceptions of participants regarding the Department of Water and Sanitation (DWS) as a water sector leader and water sector regulator. This is important because it gives insight into whether the water resource policies like the National Water Act (Act 36 of 1998) and the National Water Resource Strategy (I and II) as laid out in Section 4.1 are being implemented and the challenges and opportunities thereof and when discussed a number of responses were obtained. Almost half (47 per cent) of the participants cited that DWS is not an effective water sector leader as shown on Table 4.10. A Scientist Manager based in Kwazulu Natal stated that;

> "There is no communication between directorates of the department therefore we struggle to get monitoring information. In addition; the ever changing political leaders destabilize everything and delay service delivery. Government used to be hugely effective and was viewed with respect in the water sector when I started in DWS. Now it is just scrambling to survive, never mind being effective." (Pers. Comm., 2015c).

This view is also supported by another respondent based in Water Research Commission in Gauteng who is also of the view that;

> "DWS should be setting an example when it comes to monitoring water resources but it is unfortunate that when they have budget cuts, the first thing to be removed is monitoring equipment and the like, which demonstrates the lack of understanding of what is important. They have good strategies and plans but lack in implementation." (Pers. Comm., 2015k).

Table 4.10 Listing of perceptions on water sector leadership

Is DWS an effective water sector leader?	Frequency of citations	Total number of citations	Percentage %
Yes	III III III III III III III III III III III III III	39	40
No	III III III III III III III III III III III III III III III	45	47
Not Sure	III III III III I	13	13
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

On the other hand, only 40 per cent of the participants cited that DWS is an effective water sector leader. Below are some of the statements made by respondents during focus group discussions;

> "In my opinion DWS is a good sector leader which needs financial investment and skills retention for it to be a great sector leader." (FGD 4, 2016)

> "It is an effective leader that has proved to be efficient in the management and provision of solutions in cases where threats to the water resources are experienced. A typical example is how Acid Mine Drainage threat has been dealt with." (FGD 1, 2016)

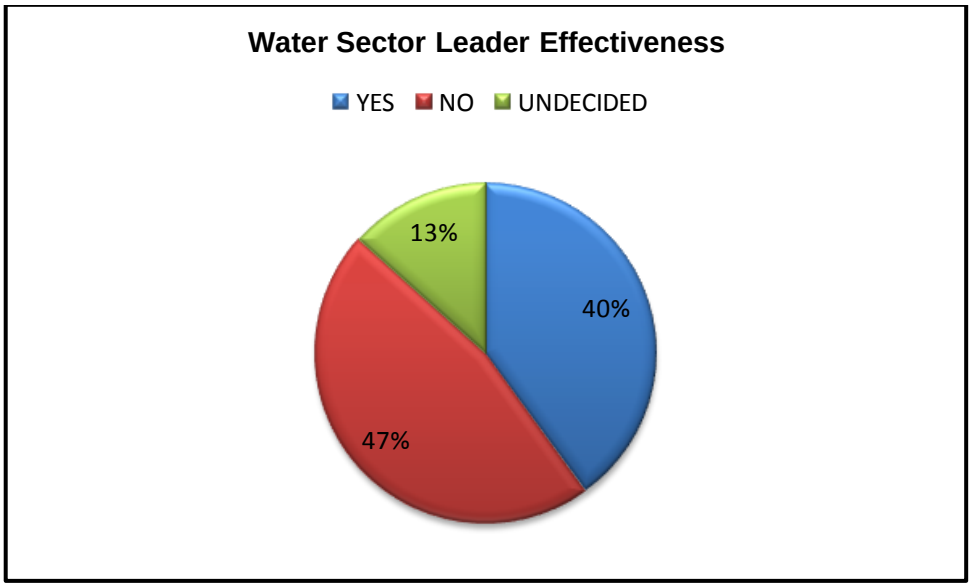

Figure 4.13 Perceptions on DWS as Water Sector Leader.

Thirteen per cent of the participants were unsure whether DWS is an effective water sector leader. During focus group discussions some of the participants cited that the DWS is doing well in some areas like sanitation because politically, the votes are in the tangible services like toilets and provision of water; however DWS is forgetting about the hydrological side of things, mostly on the monitoring network and its value. (FGD 3, 2015)

In addition to water sector leadership, the researcher explored the different perspectives of the participants towards water sector regulation and when discussed a number of responses were obtained. There were a lot of differing views and it was important to understand why that was the case. Seventy per cent of the respondents revealed that DWS is not an effective water sector regulator as seen on Table 4.11.

Table 4.11 Listing of perceptions on water sector regulation

Is DWS an effective water sector regulator?	Frequency of citations	Total number of citations	Percentage %
Yes	III III III III III III III III I	25	26
No	III III III III III III III III III III III III III III III III III III III III III III III III II	68	70
Not Sure	III I	4	4
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

A key informant based in the DWS as a Director of the hydrology section mentioned that;

> "They (DWS) are largely ineffective at this stage due to the inability to act against transgressors. It is difficult because government departments cannot act against each other. For example; government departments cannot take action against local authorities because in our constitution we got a principle of corporative governance.....**politicians also hide behind the cooperative governance to avoid taking proper action against perpetrators**." (Pers. Comm., 2015q)

This view was supported by another respondent from Tshwane municipality who said that;

> "Government is fairly inefficient in regulating itself, local authorities and regulating the public and it's partially because of political interference. Regulation is not popular because it cost votes during elections in a democracy like South Africa's. **Corruption** is a good example of the country's failure to regulate. **It's a sort of a national game to evade the law as far as you can**." (Pers. Comm., 2015b)

Another respondent from the Northern Cape regional office echoed the same sentiment by stating that;

> "Until the department stops to be a referee and player mentality, the regulation part is very much at its infancy.....I don't think DWS can support and regulate municipalities at the same time" (Pers. Comm., 2015m)

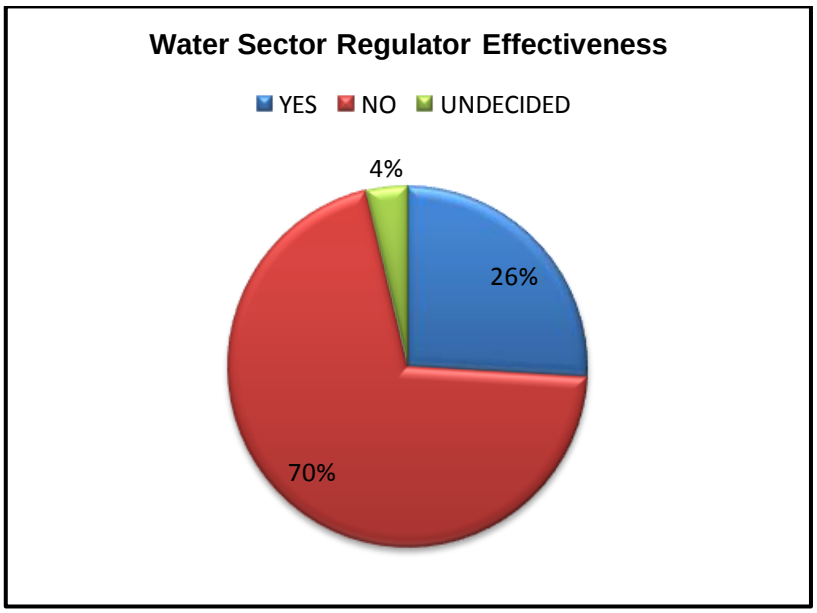

Figure 4.14 Perceptions on DWS as an effective water sector regulator.

During focus group discussions, some of the participants were of the opinion that backlogs in issuing water use licenses and compliance monitoring and prosecution of transgressors were partly to blame for inefficient regulation of the water sector. A majority of participants

suggested that regulation must be independent from the DWS to work (FGD, 2015a). Very few participants revealed that DWS is an effective water sector regulator. During focus group discussions, some of the participants mentioned that with the establishment of CMA's, DWS will work well as a regulator.

Four per cent of the respondents were undecided on whether DWS is an effective water sector regulator. They mentioned that in some respects DWS is an effective water sector regulator but in some respects, they fall short due to lack of funding and human capacity to monitor and evaluate whether policies are being implemented for effective regulation.

In view of the above sentiments, we can comfortably say that the current regulatory environment in the water sector is not conducive for the DWS to lead effectively. DWS regulations and laws are comprehensive enough but lack competent workforce and implementation. For example, a key informant based at the Water Research Commission stated that;

> "The regulations that exist in this country are generally good, the problem lies with implementation. The Blue/Green Drop audits proved that municipalities are failing on a large scale but no strong action is taken against them. Co-operative governance makes municipalities immune to be taken to task so basically as a regulator we are failing." (Pers. Comm., 2015r)

It was mentioned many times by the study participants that co-operative governance is hampering efficiency when it comes to service delivery. They went on to say that co-operative governance defeats the whole purpose of regulation and undermines the efforts of public servants. It can be said that effective governance of a country's water resources requires consideration of political, economic, administrative, social processes and institutions by which government, public authorities, communities and the private sector take decisions on how best to develop and manage water resources. In South Africa, an excellent legislative framework exists,

however its implementation has been less than satisfactory. Lack of funding, shortage of skills and political interference are some of the challenges that have been mentioned repeatedly by participants. It is very important to understand why these challenges exist and how they can be mitigated.

4.5 WATER RESOURCE MONITORING CHALLENGES

The reasons for ineffective water resource monitoring are many and they include limitations set by a lack of interest in water resource conservation and protection. This is as a result of a lack of understanding of the role of water resources management in economic and social development (GWP, 2015). South Africa lacks an effective water resource monitoring system, wherein baseline monitoring is non-existent and furthermore no sound decisions can be made on the future of water resources in South Africa. South Africa has recognized the need for an integrated approach to water resource monitoring but is still seeking effective ways of achieving this; hence the DWS Directorate; Information Programmes, which sets out to facilitate coordination and collaboration amongst the range of stakeholders involved in various aspects of water monitoring as well as to enhance synergies between their portfolios. It was aimed at ensuring well designed monitoring programmes and networks with adequate, reliable data and information management, optimised for maximum synergy through a systematic integration plan that is aligned with the objectives of the National Water Act (36 of 1998), specifically chapter 14, and Water Services Act (108 of 1997), specifically chapter 10, NWRS 2 Chapter 13, as well as the globally accepted indicators for IWRM. A number of strategies and a series of plans address the issues of integration. This includes the NWRS1, NWRS2 and the five year water quality monitoring plans which are also to improve water resources development, use, conservation and protection.

From a review of numerous articles, responses from a questionnaire and discussions with water resource monitoring stakeholders revealed that there are key problem areas that prevent efficient and sustainable management of the country's water resources which should be accordingly addressed in new legislation. In exploring the problem areas, participants in the process made suggestions as to how the problems

could be addressed in future legislation. These suggestions are recorded and developed in much greater detail below.

Using a combination of participatory research tools such as listing, brain-storming and ranking, participants in Gauteng region were asked to list and rank the different challenges that they considered most important, experienced in water resource monitoring. These views are reflected in Table 4.12.

Table 4.12 Listing and ranking of important challenges in water resource monitoring in South Africa

Category	Frequency of challenge citations by participants	Total no. challenge citations	Percent %	Rank
Lack of financial resources	III III III III III III III III III III III III III III	42	29	1
Lack of human resources and/or skilled personnel	III III III III III III III III III III III II	38	26	1
Poor governance structure	III III III III III III III I	25	17	2
Ineffective stakeholder engagement 'working in silos'	III III III III III III II	23	16	2
Inefficient data management	III III III III II	17	12	3
Total		145	100	

Source: Based on 63 face to face interviews and 5 focus group discussions in South Africa.

It is suggested in Table 4.12 that from a total of 145 challenge citations by 97 participants, 29 per cent identified lack of financial resources as the most important challenge in water resource monitoring followed by a lack

of human resources, statistically represented at 26 per cent. Seventeen per cent and 16 percent of the citations identified poor governance structure and effective stakeholder management (working in silos) respectively as the second most important challenges; while 12 per cent of the citations identified inefficient data management as the third most important challenge as seen in the pie chart below (Figure 4.15).

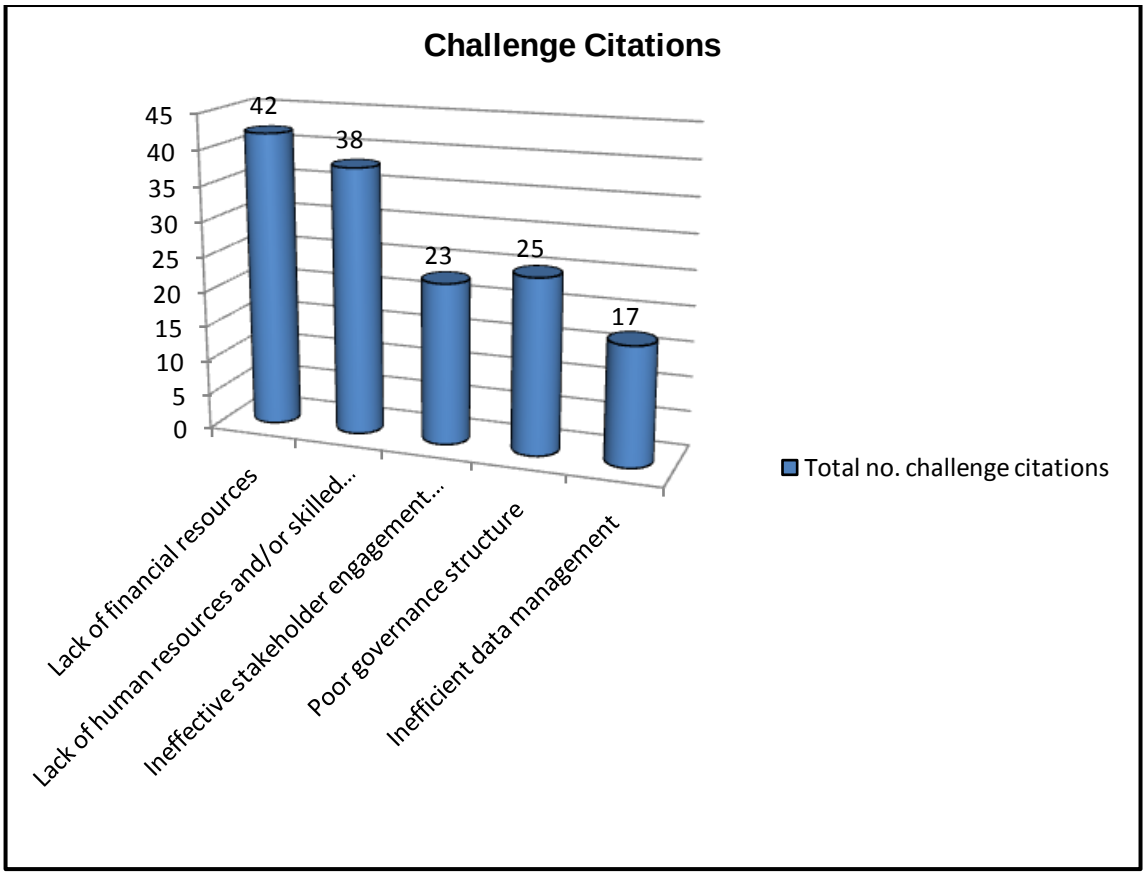

Figure 4.15 Challenges in water resource monitoring in South Africa.

I. Lack of financial resources

Lack of financial resources has arguably been the greatest obstacle to optimal monitoring programme management. Cited 42 times during the interviews and focus group discussions, 29 per cent of respondents felt that a lack of financial resources was a huge constraint that hinders sustainable water resource monitoring. It is a well known fact that development and management of water resources can only be sustainable

when planners, politicians and the public have an adequate knowledge of the resource and of the constraints within which it must be managed.

A key informant based in an environmental consulting company as a water resources planner pointed out the following;

> "There is a lack of proper funding of monitoring programmes. I don't think South Africa is spending enough money on ensuring reliable water supply for the future, it's not that there is no money, it's just not the kind of money that should be spent and what money there is, there are spending inefficiencies, but that is sort of inherent in government. It is important for the DWS to channel funds into water resource management rather than focussing only on water infrastructure." (Pers. Comm., 2015a).

An engineering technician with extensive experience based in DWS Boschkop office was of the view that;

> "The Supply Chain Management (SCM) issues we are facing are immense and prevent us from doing our work efficiently. If the government is carrying on as it currently is by making it nearly impossible to work with cumbersome and restrictive SCM procedures and cost-cutting measures - we are heading for disaster. For the first time in 38 years I am failing to collect data because I don't have hydrometrical instrumentation or even petrol to do maintenance work with.....Our children will suffer because of this period in the Department's history." (Pers. Comm., 2015b).

One of the themes that emerged under the lack of funding is theft and vandalism of monitoring infrastructure. One hydrologist based in the DWS national office pointed out that theft and vandalism of monitoring equipment has resulted in the expensive exercise of replacing monitoring equipment and thereby eating into the resource monitoring budget (Pers. Comm., 2015f). The statement below made by a technical manager based

at DWS Kwazulu Natal regional office indicated that theft and vandalism of equipment is a huge constraint that needs to be addressed in order to have a sustainable water resource monitoring network that provides the technical teams the data they need for planning.

> "Vandalism of monitoring equipment makes it difficult for us to collect good quality monitoring data, it sets us back as we must replace equipment and that usually takes a long time with the current SCM procedures.....ultimately this causes big gaps in our data and makes it difficult to analyse the data." (Pers. Comm., 2015d).

The views expressed by the respondents above seem to suggest that theft and vandalism of monitoring equipment is partly to blame for the inadequate funds for water resource monitoring. This is because stolen equipment needs to be replaced and those funds need to come from the same pool of money that is meant to run water resource monitoring programmes sustainably.

In view of the above, the researcher sought more insight into the challenge of funding in water resource monitoring. During interview and focus group discussions respondents were asked to state if the annual budget set aside for monitoring is sufficient and a number of responses were obtained. One of the DWS national office respondents mentioned that;

> "The water monitoring function of the DWS does not enjoy the priority it deserves so the budget will always be insufficient. The money is too little to maintain stations, field visits, and assessment of stations." (Pers. Comm., 2015g).

Supported by Figure 4.16 and Table 4.13, a large percentage of respondents (53 per cent) cited that the budget set aside for water resource monitoring is inadequate and it was important to understand why that was the case.

Table 4.13 Listing of perceptions on water resource monitoring annual budget

Is the water resource monitoring budget sufficient?	Frequency of citations	Total number of citations	Percentage %
Yes	III III III III III III III III III II	29	30
No	III III III III III III III III III III III III III III III III III III III	51	53
Not Sure	III III III III III II	17	17
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

A director based in DWS national office pointed out that;

> "The DWS as a whole has experienced budget constraints in the last few years and hence cost cutting measures have now been put in place across the board. We are underinvested when it comes to monitoring but have many highly paid individuals in the DWS, it has become a top heavy organization and that money could be better utilized in water resource monitoring." (Pers. Comm., 2015j)

And this view is also supported by a researcher who is based at the University of Pretoria who was also of the view that;

> "Climate change impacts like floods are felt first by the monitoring equipment which will need to be replaced or fixed at a more frequent rate which needs a higher budget." (Pers. Comm., 2015c).

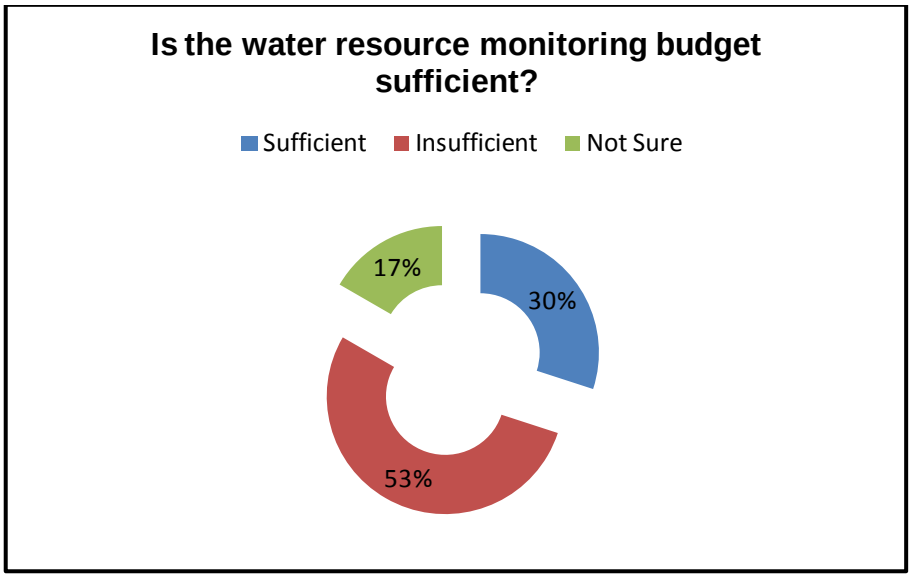

Figure 4.16 Water Resource Monitoring Budget

Surprisingly, 30 per cent of the study population cited that the budget was sufficient for water resource monitoring. The following statement was made by a laboratory technician based at RQIS in Gauteng;

> "The budget is enough for laboratory analyses and fieldwork but not enough for general maintenance of monitoring sites" (Pers. Comm., 2016f).

Another respondent from the North West regional office added that;

> "I do believe that if we utilized the money we receive properly it should be enough but the main challenge is that the regions fail to use the entire budget they have been allocated and the funds are returned at the end of the financial year." (Pers. Comm., 2016q).

These statements illustrate that there is a perception that funds allocated for monitoring are enough but are not being utilized efficiently.

Lastly; 17 per cent of the study population cited that they were not sure if the budget was sufficient for the monitoring of water resources. Most of the participants mentioned that they did not know what the actual budget

was. The following statement was made by one of the participants during a focus group discussion;

> "I don't know if the budget is sufficient, because I don't know what the numbers are so I will not pragmatically say the budget is not enough but I do believe lack of human resource makes it more difficult to do our jobs." (Pers. Comm., 2015r)

Furthermore; a respondent recommended that external stakeholders share the cost of monitoring or conduct monitoring on a rotational basis, that way, trust relationships are built and ultimately, the environment will foster accountability among stakeholders. (Pers. Comm., 2015q)

II. Lack of human resources and/or skilled personnel

Cited 38 times during the interviews and focus group discussions, 26 per cent of respondents felt that a lack of human resources also presented a major challenge in water resource monitoring in addition the lack of funding. During a focus group discussion, a respondent based at the DWS Gauteng regional office stated that;

> "Lack of human resources is a huge challenge.....South Africa does not have enough water scientists, engineers and technicians. The few that are qualified readily take up opportunities outside of South Africa to develop their careers." (Pers. Comm., 2015i)

Retirement of qualified and experienced staff was also mentioned as a great challenge, as they tend not to handover responsibilities as they should and the institutional memory in terms of data and 'know-how' is lost to the DWS (Pers. Comm., 2016c). In depth discussions with different respondents revealed that human resource challenges prevented them from carrying out some of the important water resource monitoring responsibilities. One deputy director based at DWS national office participant pointed out that;

> “DWS has a lot of vacant posts but unfortunately there is also a high staff turnover, even if the posts are filled, the candidate leaves after training to explore other opportunities, we struggle to retain staff.” (Pers. Comm., 2015m)

And this view is also supported by another manager based in the same organization who was also of the view that;

> “Staff migration to different areas of responsibility made it difficult to fulfill all monitoring responsibilities” (Pers. Comm., 2015f).

Other participants indicated that there is a lack of capacity to manage monitoring efficiently and the lack of experienced personnel made the situation even worse (Pers. Comm., 2015c).

An interesting aspect of private observers was mentioned by a technical manager based at the DWS Northern Cape regional office;

> “Private observers are civilians that take evaporation, rainfall etc. readings and are contracted by the DWS and may be representatives of water user associations, parastatals or private organizations that are assisting DWS to undertake this mandate or private individuals contracted to do the function.”

The respondent went on to say that;

> “The numbers of private observers are dwindling because (1) they are not being paid timeously, (2) the deceased are not being replaced; and this results in gaps in rainfall data.” (Pers. Comm., 2015h)

In view of the above commentary; it was then important to understand to what extent Human Resource strategies within the DWS were promoting competence in water resource monitoring functions. A number of responses were captured. During an interview one participant stated that;

> "We have fewer scientists left in the DWS that are currently doing the job of at least three people each, where will they get the time to pick up discrepancies when analysing data, that is the reason we have questionable data." (Pers. Comm., 2016t).

This is an indication that the strategies in place are not effective because the DWS cannot attract and retain technical staff to process water resource monitoring data. It was noted that; in terms of training, Human Resources (HR) seems to be doing their best to train officials and it is up to the employee to enrol themselves in courses etc. especially when it comes to graduates joining the DWS through the Learning Academy. One manager based at the DWS national office mentioned that;

> "DWS invests money and time in the form of the Learning Academy in the form of bursaries, training and professional registrations into training young scientists but end up losing them to private companies for better salaries and better working environment" (Pers. Comm., 2016h).

A specialist scientist based at DWS national office alluded to the above comment by noting that;

> "DWS shoot themselves in the foot by not having good structures to accommodate people of that calibre because we train the Graduate trainees and then we have to put them out on the market. We find it difficult to appoint them in the DWS because HR policies say there must be free competition for posts, you cannot train a Graduate Trainee and then put them in a post, you have to advertise and allow everybody an equal opportunity to apply for it." (Pers. Comm., 2015f).

And this view is also supported by another technical manager based in the Free State regional office who is also of the view that;

> "The minimum period for any engineer to transfer at least some skills is five years of overlap with new/young engineers. The few engineers left in the department are all above 60 years old; meaning even any recovery started now will be too late." (Pers. Comm. 2015n)

It is clear from the commentary above that the DWS is experiencing loss of institutional memory through retirement due to a lack of skills transfer plans and lack of retention strategies. It was found through key informant interviews that the DWS had neither retention strategy nor did they have succession plans for their current staff complement. During focus group discussions, many participants mentioned OSD (Occupation Specific Dispensation) packages and the Learning Academy as ways in which the DWS was striving to promote competence, attract and retain water resource monitoring technical staff.

In light of the above observations, it was also important to understand the staff complement in water resource monitoring and challenges experienced by the professionals in the water sector. The researcher looked at the participants' employment data and hierarchy in their place of employment. It was found that the average DWS employee has ten years of work experience. This can be seen on Figure 4.17. It is also suggested in Table 4.14a that from a total of 63 participants based at the DWS, 40 per cent had six to ten years work experience within the DWS; 33 per cent had less than five years work experience, 17 per cent had 11 to 20 years work experience and three per cent had 21 to 30 years work experience. While six per cent had over 30 years work experience in the DWS. This illustrates that the DWS is an organization with a high number of inexperienced individuals and a very low number of experienced individuals in terms of water resource monitoring responsibilities.

Table 4.14a Listing of number of years in DWS service

Number of years in DWS service	Frequency of citations	Total number of citations	Percentage %
0 to 5 years	III III III III III III III	21	33
6 to 10 years	III III III III III III III III I	25	40
11 to 20 years	III III III II	11	17
21 to 30 years	II	2	3
31 to 40 years	III I	4	6
TOTAL		63	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

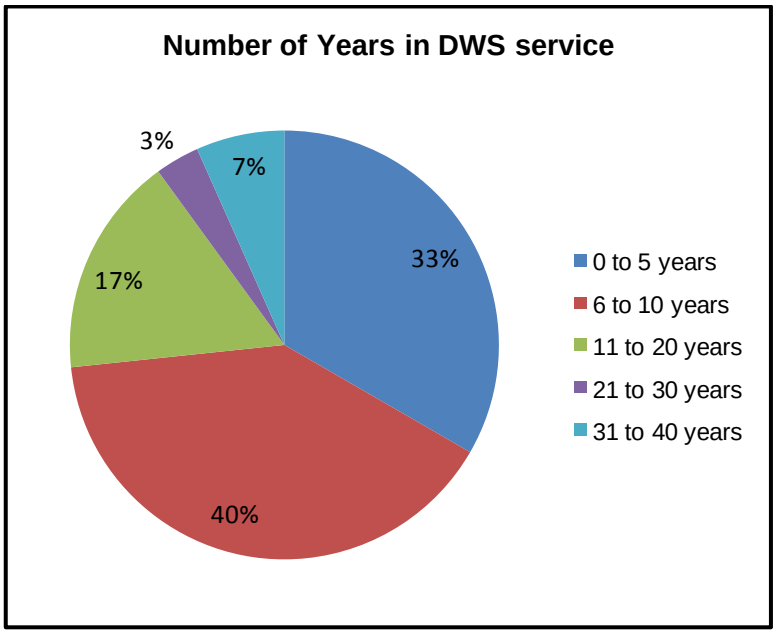

Figure 4.17 Years of experience in DWS service

When looking at the number of years participants worked in the water sector as a whole i.e. private companies, other government departments and educational institutions involved in water resource monitoring, it was found that 50 per cent of the participants had six to ten years work experience in the water sector as seen on Figure 4.17, seventeen per cent had less than five years work experience, 20 per cent had 11 to 20 years work experience and six per cent had 21 to 30 years work experience, while seven per cent had over 30 years work experience in the DWS. Also, the data for the sampled population of 97 participants, the average number of years in service is 12 years.

Table 4.14b Listing of number of years in the water sector

Number of years in water sector	Frequency of citations	Total number of citations	Percentage %
0 to 5 years	IIII IIII IIII IIII IIII I	16	17
6 to 10 years	IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII IIII I	49	50
11 to 20 years	IIII IIII IIII IIII IIII IIII I	19	20
21 to 30 years	IIII IIII	6	6
31 to 40 years	IIII IIII I	7	7
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

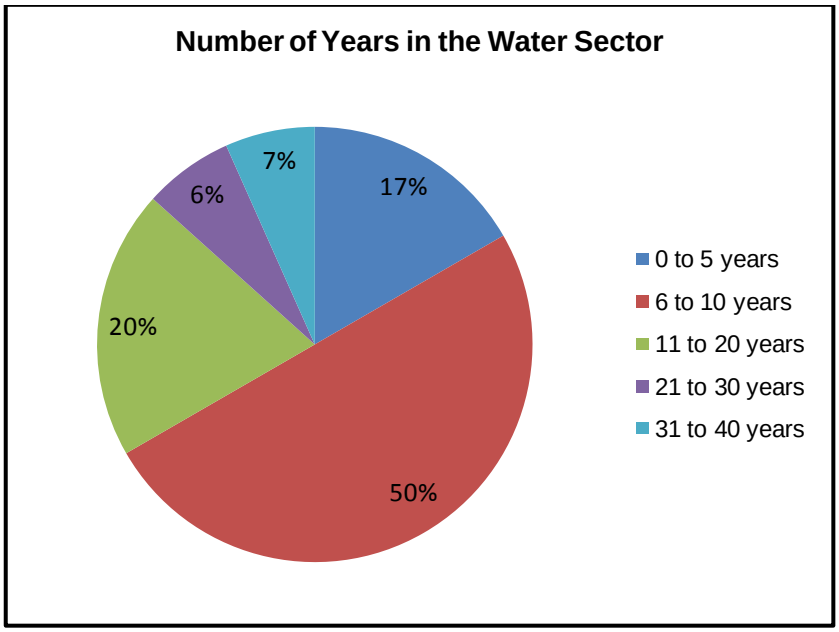

Figure 4.18 Years of experience in the water sector

It was found that in the water sector, 43 per cent of the participants were between the ages of 23 and 35 as seen on Table 4.15 and Figure 4.19, while 57 per cent of the participants were between the ages of 36 and 55. This shows that there are more respondents closer to retirement than there are younger participants.

Table 4.15 Listing of age groups in water sector

Age Groups	Frequency of citations	Total number of citations	Percentage %
23 – 35	IIII III III III III III III III III IIIIII III III III	42	43
36 – 55	III III III III III III III III III IIIIII III III III III III III III III I	55	57
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

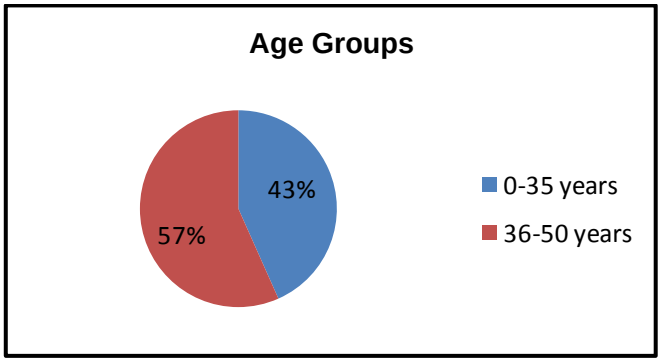

Figure 4.19 Age groups in the water sector.

A question that was important to ask was around the roles and responsibilities of the respondents in the water sector and when discussed a number of responses were obtained. The hierarchy and roles of participants in the water sector are illustrated in the table below (Table 4.16) categorized as junior, middle and senior management and their respective responsibilities.

Table 4.16 Hierarchy and roles of participants

Hierarchy	Roles	Responsibilities
Junior Management	Graduate trainee Candidate Scientist Environmental Officer	Manage and control, protect water resources (streams, wetlands and quarries) and sources (water users, mines, local government, agricultural activities and their impact on water resources). Protecting water resources through water user authorizations and monitoring and sampling on a monthly basis. Attend to pollution incidents; we hold water quality forums to share status of the water resources.
Middle Management	Scientist Manager Scientist Production Scientist Hydrologist Deputy Director Assistant Director Water Quality Advisor Engineering Technician Water Resources Planning Consultant	Acquire and audit groundwater and surface water data from dams and rivers for example the use of biota riparian and in-stream biological information to determine the ecological status of the water resource. Administrative role due to shortage of staff. Dissemination of information to other directorates, and educational institutions. Manage and control, protect water resources (streams, wetlands and quarries) and sources (water users, mines, local government, agricultural activities and their impact on water resources). Protecting water resources through water user authorizations and monitoring and sampling on a monthly basis. Attend to pollution incidents; we hold water quality forums to share status of the water resources.
Senior Management	Research Manager	Offer expert advice to projects/assignments which requires expertise in information management and/or hydrology or close support to management

	Specialist Scientist Water Quality Specialist Director	projects.

Source: Based on 63 face to face interviews and 5 focus group discussions in South Africa (June 2015 - June 2016)

It was found that 60 per cent of the participants hold posts in middle management level, 23 percent of the participants hold posts in senior management level, while 17 per cent hold posts in the junior management level as seen on Table 4.17 and Figure 4.19.

Table 4.17 Listing of participant roles in the water sector

Participants roles	**Frequency of citations**	**Total number of citations**	**Percentage %**
Senior Management	III III III III III III III I	22	23
Middle Management	III III III III III III III III III III III III III III III III III III III I	58	60
Junior Management	III III III III III II	17	17
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

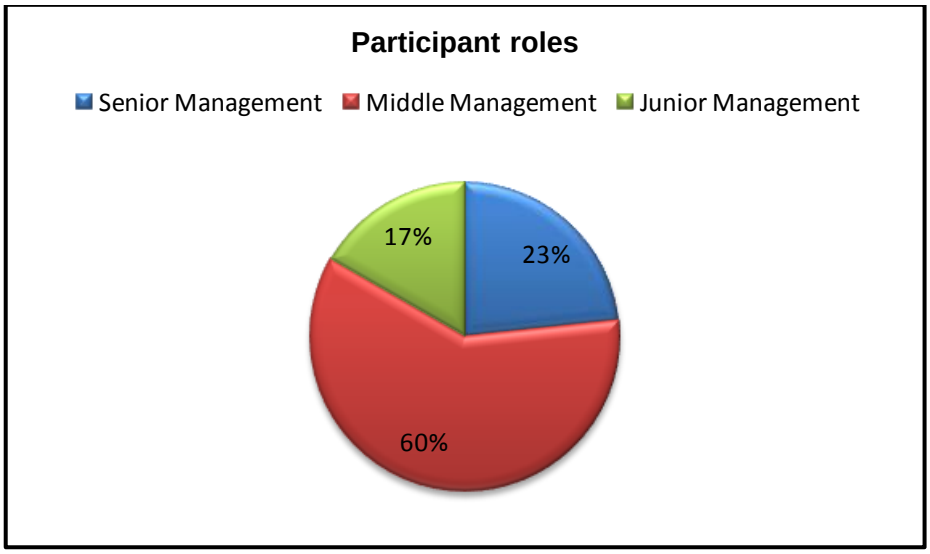

Figure 4.20 Participants roles – senior, middle and junior management

In terms of training and development, a large percentage (61 per cent) of respondents cited that the training undertaken was of a technical nature as seen on Table 4.18 and Figure 4.21 below.

Table 4.18 Listing of training and development in the water sector

Participants roles	Frequency of citations	Total number of citations	Percentage %
Technical	III III III III III III III III III III III III III III III II	59	61
Professional Development and Leadership	III III III III III III III III III III III I	34	35
Mentorship	III I	4	4
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

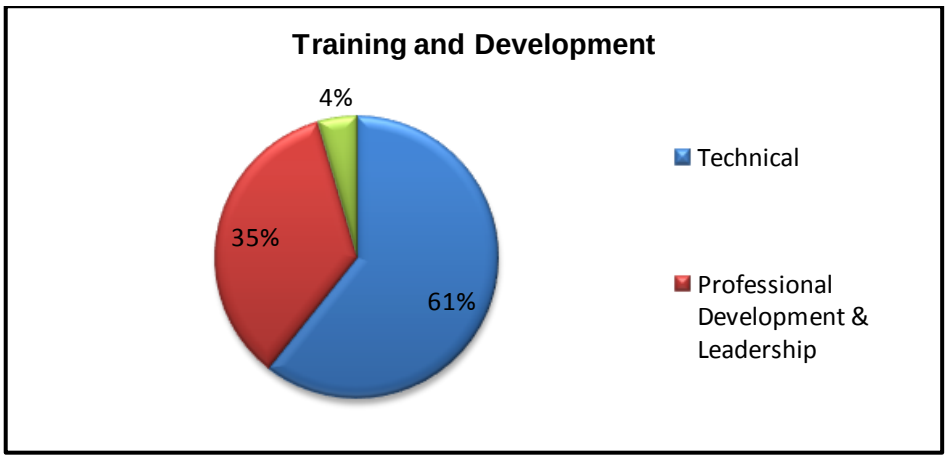

Figure 4.21 Training and development of participants.

In response to the above question; one of the respondents based in the DWS Boschkop Satellite office pointed out the following;

> "We used to have in-house technical training at Boschkop, it is sort of in-service training which included assessment of stations, calibration of instrumentation, technical issues and maintenance of monitoring stations." (Pers. Comm., 2015c).

Another respondent based in the DWS national office added that;

> "I have undergone eco-status training, surface and groundwater hydrology training – I need these courses to help me with my data collection duties."(Pers. Comm., 2015e).

Other respondents mentioned formal degrees and courses obtained from various universities. One technical manager based in the DWS national office pointed out that;

> "I received Certificates in Flood hydrology and flood hydraulics from the University of Pretoria and Flood Studies from the University of

> Stellenbosch and currently PhD candidate in River Hydraulics at University of Kwazulu Natal." (Pers. Comm., 2015d).

The views expressed by the majority of participants above seem to suggest that technical training is deemed more important than any other type of training in water resource monitoring. This is because data collection, analysis and dissemination are all part of the water resource monitoring cycle. Thirty five percent of the training undertaken by participants was management training. This refers to a wide variety of specialized training, formal education or advanced professional learning. This can include project management and some of the soft skills aimed at developing managers. During interviews, one of the research managers at the Water Research Commission stated that;

> "I did courses in business process management, project management, business administration and management development programme." (Pers. Comm., 2015b).

Four per cent of the training undertaken by the participants was mentorship. Below are some of the comments made by mentors and mentees. One technical manager based in the DWS national office mentioned that;

> "I conduct training for graduate trainees and mentor candidate scientists aspiring to be professional scientists." (Pers. Comm., 2015m)

A graduate trainee based in the same organization mentioned that;

> "I joined the department in 2008 as a graduate trainee and today I am a candidate scientist hoping to be registered as a professional scientist soon" (Pers. Comm., 2015t).

There is a direct relationship between mentorship and years of experience. The mentor participant mentioned above has been in the

Department of Water and Sanitation for 36 years which indicates a wealth of experience, while the mentee participant only has seven years experience in the Department of Water and Sanitation.

III. Poor governance structure

It is well known that one of the biggest challenges in water resource management is one of governance, not of a technical nature. Effective water resource management at local, regional and national level can only be achieved if a robust institutional structure exists. The general consensus in the South African water sector is that water resource management functions should be delegated to the lowest technically competent level. Therefore a training and education programme at local or lowest level is a requirement to realize the goal of optimal management of water resources in the country. Cited 25 times during interviews and focus groups, 17 per cent of respondents identified poor governance structure as a hindrance to efficient water monitoring as shown in Figure 4.10. A water quality specialist from Rand Water stated that;

> "The nature of the challenges experienced in the monitoring space is institutional, rather than technical. DWS is the primary institution for managing water resources but they don't have a good handle on monitoring and there doesn't seem to be sufficient realization at higher levels about the urgency of proper water management." (Pers. Comm., 2015h).

A key informant based in the DWS national office working as a specialist scientist mentioned that;

> "DWS should become like other government departments and establish agencies to take over some of the responsibilities like monitoring. They are trying with the CMA's but it's not happening fast enough" (Pers. Comm., 2015c).

During focus group discussions, many respondents alluded to poor governance structure as a hindrance to water resource monitoring. A participant further reiterated on the governance challenge by stating that;

> "The problem is, the management of those institutions don't regard monitoring as a key priority despite having the mandates to do that. They still don't regard monitoring as important as it is not generating any revenue for them. The government is moving away from employing technically proficient or trained individuals who are fit to do the job and just hiring their buddies who are usually not competent to do the job." (Focus Group 2, January 2015).

Another participant stated that;

> "Fragmentation between regional and national monitoring programmes – there is no clear allocation of what the roles and responsibilities are, where do national responsibilities stop and where do regional responsibilities start? Most of the monitoring programmes were set up a long time ago, to achieve certain objectives, but the objectives of these monitoring programmes have changed over time and there has not been a review of the new needs.....Moreover there is lack of financial resources and no clear indication whether national monitoring programmes are funded by national or regional budgets." (Focus Group 4, August 2015)

We see a lot of the same view and it was interesting to understand why that was the case. When we look at the picture created here it depicts themes of **accountability**, **political will** and **unclear roles and responsibilities**. They have become important issues of discussion that need to be expounded upon. Under the governance theme, the concept of **accountability** or the lack thereof, came up a few times during focus group discussions and key informant interviews. The general feeling is that, no one wants to take responsibility for water resource monitoring,

moreover, no one wants to report on the status of water resources. The reason for this may be that there is insufficient data for analysis because water resources have not been monitored due to lack of resources (financial and/or human). An environmental officer based in the DWS Gauteng regional office pointed out that;

> "Since the inception of Gauteng Integrated Water Monitoring Committee in June 2014 in the region, the terms of reference for the committee have not yet been signed hence; the committee doesn't have direction and leadership."(Pers. Comm., 2016k)

Politics will always have an influence on how water resources are managed. Administration is changed every five years, and the change brings about new appointments, new leaders with different priorities. During interviews, issues concerning the political environment with regards to water resource monitoring were discussed and one respondent from Northern Cape regional office stated that;

> "The challenge with implementation of policies is with the ever changing political environment, in other words the change of management at a political level has a great impact on the overall core function on the institution. It is very difficult to maintain the culture of the institution with these changes because every Minister and Deputy Minister would like to leave a legacy and sometimes these legacies deviate from the culture of the institution." (Pers. Comm., 2015h)

Unclear roles and responsibilities was another theme that emerged from focus group discussions and interviews. One technical manager based in regional office commented that;

> "We lack capacity in that we might have warm bodies but do they know their duties and do they know why they are doing it? We need to train people to be competent in their jobs" (Pers. Comm., 2015j).

Another respondent based in DWS national office further reiterated the issues pertaining unclear roles and responsibilities by mentioning that;

> "With the Catchment Management Agencies being established; most regional employees are still trying to find their feet, they don't know who is doing what and when. They don't have an understanding of how their roles will change." (Pers. Comm., 2015g).

IV. Ineffective stakeholder engagement - 'working in silos'

Cited 23 times during the interviews and focus group discussions, 16 per cent of respondents felt that ineffective stakeholder engagement presented a sizeable challenge in water resource monitoring as seen on Figure 4.15. When this issue was discussed in a focus group, a respondent based in the co-ordination and liaison section of the DWS National office stated that;

> "There is a need to engage local municipalities as they are struggling in terms of monitoring and their issues could be addressed if their needs are expressed or shared on the correct platforms." (Pers. Comm., 2016d)

In the same focus group, another respondent from the Gauteng regional office mentioned that;

> "There is a lack of alignment of monitoring programmes and this contributes to ineffective stakeholder engagement. There is also a serious lack of communication among stakeholders therefore we end up duplicating responsibilities and wasting money." (Pers. Comm., 2015q).

Reiterating this phenomenon, another respondent based in the Free State regional office stated that;

> ".....Also **silo mentality** is contributing to the current situation in water resource monitoring.....Department of Water and Sanitation needs to have those links with private sector and industry and integrate monitoring programmes to save on financial resources." (Pers. Comm., 2015t).

The lack of stakeholder engagement leads to a **lack of monitoring programme integration**. A researcher based at the University of South Africa was quoted saying;

> "Is it appropriate to give stakeholders the responsibility of sampling/monitoring and be totally dependent on their results? What are the ethics guiding this in relation to integration of monitoring programmes? Moreover, is it legal? In terms of maintaining trends in this integration, who will be responsible for continuity?" (Pers. Comm., 2015s)

A water quality officer from Rand Water had a concern that;

> "If we are to integrate the different monitoring programmes between us and our stakeholders, is our data secure, we do not want to be exposed. Who will have access to the data? What will the data be used for?" (Pers. Comm., 2015h)

A scientist from the DWS national office stated that;

> "The futile attempt in making the Integrated Regional Water Monitoring Committee (IRWMC) work proves to me that stakeholders do not want to engage. They do not want to participate; they only want to blame the government when things go wrong." (Pers. Comm. 2015p).

In this regard, a new forum was formed in the Gauteng regional office in July of 2014 and has not been successful and one of its objectives was to create awareness of the status of the water resources and new

developments. Most respondents recognized that monitoring is a joint responsibility between government and private sector and both need to promote the sustainability of our water resources and their monitoring programmes. They mentioned that it is especially important to engage the communities and municipalities in terms of disaster management. Moreover, provision of scientific and technical advice was one of the ways in which stakeholder engagement can be carried out.

A question that was important for us to ask was about the communication channels used to share information within the water sector and when discussed a number of responses were obtained. Figure 4.22 below illustrates that there are a number of ways water resource monitoring data can be communicated and it was found that electronic channels are being utilized the most. The most used channel is DWS websites for example; the hydrology website that provides online data on floods/incidents, open to consultants and universities.

A respondent from the DWS regional office was of the view that emails are used to exchange data and information stored in word and excel files on official computers. The danger in this is; some national and regional officials keep their data on excel worksheets and in software not approved by the DWS where no one else has access to them, moreover; when the official's computer crashes or goes missing, the data is gone forever. (Pers. Comm., 2015t)

As seen on Table 4.19, 46 per cent of the respondents cited that websites are the most utilized forms of communication for sharing and monitoring data and/or information. One technical manager based in the DWS national office mentioned that recently was launched a National Integrated Water Information System (NIWIS) that contains dashboards reflecting information on surface water flow and river flow, dam levels, groundwater levels, water use licensing, borehole data (Pers. Comm., 2016e).

Table 4.19 Listing of communication channels

Communication channels	Frequency of citations	Total number of citations	Percentage %
Websites	III III III III III III III III III III III III III III III	45	46
Reports	III III III III I	13	14
Email	III III III III	12	13
Forums	III III III II	11	11
Information Management Software	III III II	8	8
Telephonic	III II	5	5
Personal contact	III	3	3
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

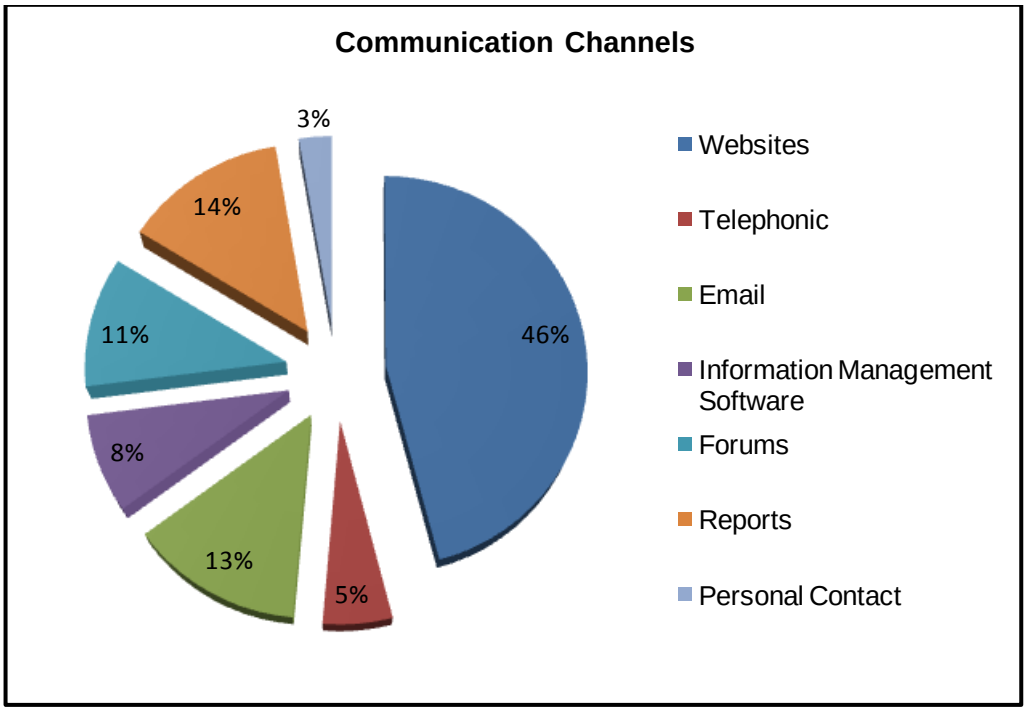

Figure 4.22 Communication channels within the water sector

During interviews, forums and reports were mentioned as being good communication channels as they revolve around sharing of data in the presence of most if not all stakeholders allowing for frequent reporting. Lastly, the least utilized communication channels are personal contact and telephones only accounting for three per cent as seen in Figure 4.22

V. Inefficient data management

Cited 17 times during the interviews and focus group discussions, 12 per cent of respondents felt that a lack of efficient data management hinders sustainable water resource monitoring as seen on Figure 4.15. A scientist from the DWS Gauteng regional office pointed out that;

“If we look at data from Water Boards for example, you will find up to date information. You can’t trust data from the DWS and it is unfortunate that having that oversight role, you find yourself in that position and it’s part of the reason why DWS doesn’t see certain things coming or challenges like disease outbreaks.” (Pers. Comm., 2016e)

Another technical manager based in the same organization supported this view by stating that;

“We are experiencing problems analysing data because it’s incomplete, moreover the data is stored in different formats that make it difficult to generate information from as we work in silos and then standards between institutions are not the same which affects data sharing.” (Pers. Comm., 2015j)

In light of the views expressed by participants in the above section, another important aspect that researchers considered important was the need to have a detailed understanding of how the participants understood the drivers of inefficient data management. The study participants were asked to consider quality assurance and quality control of water resource monitoring data. More than half of the respondents cited that data quality assurance and control were not of an acceptable standard represented at 73 per cent on Figure 4.24. Twenty seven per cent stated that monitoring data quality assurance and control were of an acceptable standard.

Table 4.20 Listing of participants’ perceptions on data quality assurance and control

Is quality of monitoring data acceptable	**Frequency of citations**	**Total number of citations**	**Percentage %**
Yes	III III III III III III III III II	26	27
No	III III III III III III III III III III III III III III III III III III III III III III III II	71	73
TOTAL		97	100

Source: Based on 5 focus group discussion and 63 interviews in South Africa (June 2015 – June 2016)

Most of the participants indicated that water monitoring data was not of an acceptable standard. A scientist based in DWS national office stated that;

“There are many exit points of non-verified, non-regulated and non-copy protected information in DWS.” (Pers. Comm., 2015u).

Another respondent, a candidate scientist in the same organization was also of the view that;

“Monitoring data is not of an acceptable standard, as currently there is a backlog in calibration of instrumentation which affects quality of data. In terms of water quality some labs are not accredited and there are no data collectors.” (Pers. Comm., 2015e).

A key informant who works at DWS national office with extensive experience in water resource management echoed the same sentiment and added that;

“Data quality is not nearly where it should be, mostly because we are operating at 30 per cent capacity in terms of human resources, we are simply bringing data in, doing minimal editing. I wouldn’t trust the data that comes from the DWS.” (Pers. Comm., 2015k).

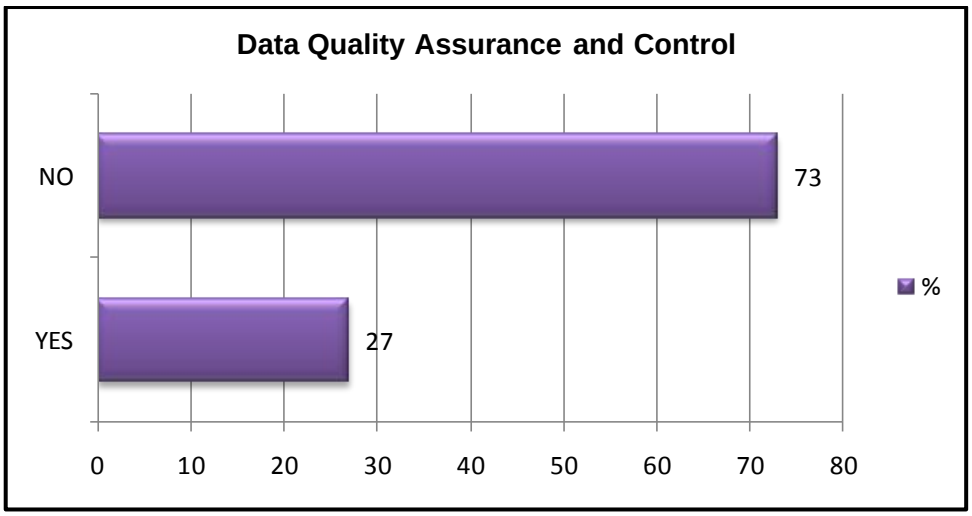

Figure 4.23 Perception of respondents towards data quality control and assurance.

Only a handful of participants indicated that water monitoring data was of an acceptable standard. One deputy director was quoted saying;

> "The Water Management System (WMS) information managers in the Department of Sanitation check the data and monitor all the data that goes into that system." (Pers. Comm., 2015n)

From literature, we understand that the process of data management begins with data collection, followed by data analysis and data dissemination in the form of reporting. The participants were asked to state which categories they work in or are involved in. Thirty eight per cent of the participants' roles involve data dissemination, 25 per cent of the participants cited that their roles involve data collection and 37 per cent involved data analysis as seen on Figure 4.24. In these categories it was found that the roles in the region are more around the data collection stage and national roles revolve around data analysis and dissemination.

Table 4.21 Listing of participant roles in data management

Participant roles in data management	Frequency of citations	Total number of citations	Percentage %
Data collection	III III III III III III III III	24	25
Data analysis	III III III III III III III III III III III III III III	36	37
Data dissemination	III III III III III III III III III III III III I	37	38
TOTAL		97	100

Source: Based on 5 focus group discussion and63 interviews in South Africa (June 2015 – June 2016)

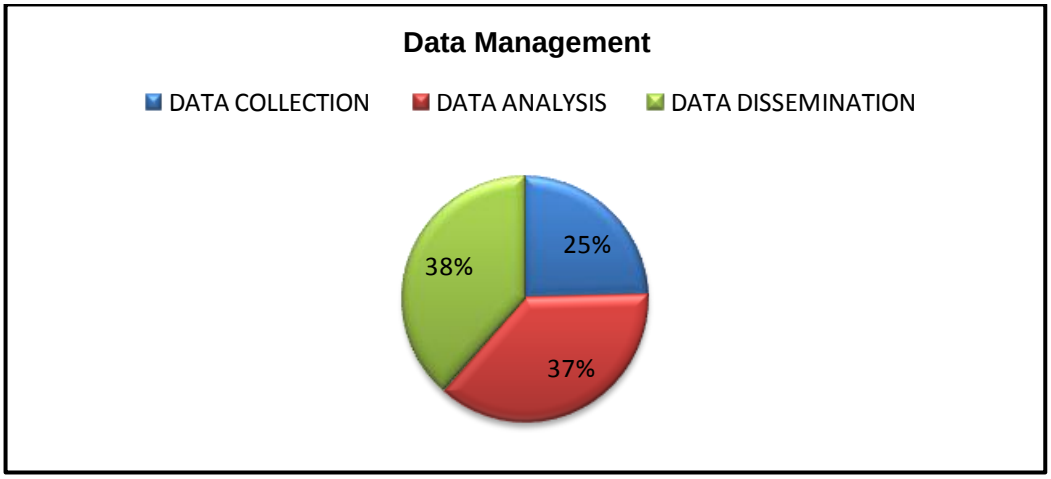

Figure 4.24 Participants' roles in different stages of data management

One of the themes under data management is a **lack of competent laboratories** and **use of technology.** A representative from RQIS mentioned that;

> "We have no resources or accredited laboratories to help us do our work. We are contracted to some laboratories but still experience

> gaps in information and reliability of data is also an issue- not all labs are fully accredited and results may not be accurate." (Pers. Comm., 2015d)

Another respondent, a key informant based at DWS national office, mentioned that;

> ".....another challenge is the use of technology; it's got two sides to it. We want to use the advanced technology for online monitors however in South Africa it's not going to work because of theft and vandalism." (Pers. Comm., 2015k)

An interesting observation was made by a respondent from the hydrology section at DWS national office when they stated that;

> **"**Availability of technology is a problem, we can't purchase technology in an efficient way as they (SCM) are bungling up contracts and messing things up – government inefficiency again." (Pers. Comm., 2014c)

There were many similar views that illustrated that monitoring data management is not up to the required standard due to the above-mentioned challenges. The scenarios created here are examples of fragmentation in the water monitoring institutional framework.

Overall, the findings in this chapter have revealed that water resource monitoring governance is a global challenge and creates a space where stakeholders internal and external to the DWS are dynamic players in shaping the issues of common interest. As such, the need for strategies to the current development challenges such as; lack of co-ordination among departments, lack of financial and human resources, absence of risk based monitoring; monitoring performance evaluation and failure to address client needs are well documented. This reflects weak institutional frameworks where there are attempts for implementation. Another study finding indicated that there is a growing demand for policy reform to

address these challenges and close the gaps and limit the rapid change in water management institutions. It appears that the power of politics coupled with inefficiency of government in the local and national contexts undermine the sustainable development of water resource monitoring. Achieving the goals of a sustainable water resource monitoring in the context of South Africa would require a shift in the way monitoring structures are governed. While governance structures exist in the region, a great deal of work must still be done to encourage participation in water resource monitoring activities and forums and integrate all monitoring programmes for maximum synergy.

CHAPTER FIVE

ANALYSIS AND DISCUSSION

5.1 INTRODUCTION

In light of the empirical findings in the previous chapter, this chapter will discuss what the findings mean in the context of this research. The findings have unveiled a myriad of issues which are affecting the sustainability of water resource monitoring in South Africa. Among others are a lack of funding and skills, political interference, poor governance structure, inefficient data management and ineffective stakeholder engagement and impacts of climate change and urbanization. To ensure that there is a clear understanding of the key issues and how they are linked; the discussion is structured in a way that will address the research aims and objectives as mentioned in the first chapter which will be informed by the literature. The research aims and objectives deal with three major themes of the research; water resource monitoring sustainability, monitoring governance and challenges in South Africa which will be addressed in this chapter.

5.2 REVIEW OF EXISTING WATER RESOURCE MONITORING POLICY

South Africa's water sector has a sound legislative framework in the form of the Constitution, the National Water Policy White Paper, the National Water Act (NWA) and the National Water Resource Strategy (I and II) (NWRS I and II). Ideally, water legislation should provide principles and priorities that guide decision-making in the water sector (Salman et al., 2006). These can include conservation and protection of the State's water resources, equitable division of the resource among all potential users, sustainable use of water resources, use of water to promote economic development, and efficient management of water resources. The concept

of Integrated Water Resources Management (IWRM) is increasingly being stated as one of the principles where water is perceived to be an integral part of the ecosystem, natural resource and social and economic good (Salman et al., 2006). In order to sustainably manage water resources, good planning is required and this suggests that each jurisdiction develops plans on how it will manage and regulate its water resources (Salman, 2006).

Institutional arrangements are an important aspect in water legislation for dealing with water resources. The advantage of such arrangements is that one or more government agencies such as ministries, national councils, agencies, and commissions, are assigned responsibility over water resources which include “allocation and supervision of water rights and the preparation of programmes, and policies, as well as enforcement provisions” (Salman, 2006). And more importantly, the line of responsibility should be made clear to avoid duplication and overlapping of responsibilities and agencies should be provided with financial and administrative autonomy and the liberty to manage without political interference (Salman, 2006).

The establishment of basin management authorities that are responsible for developing water management plans for a specific basin are one of the ways to reflect decentralization of decision making and public participation (Salman, 2006). This approach of decentralization and public participation in water management would incorporate two of the Dublin Principles, namely; Principle 1 -Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment and Principle 2 - Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels (Salman, 2006).

Some legislation provides for the establishment of Water User Authorities and Advisory Committees where all entities and organizations concerned

with water would be represented including civil society organizations and academic institutions. These bodies would assist the government in preparing water policies, programmes and plans, and in coordinating their implementation. “Indeed, public participation in the design and implementation of water policy and legislation is now considered an important element in ensuring the success of the policies and the legislation” (Salman, 2006).

The institutional arrangements in South Africa for water resource management are embedded in the NWA of 1996. This Act gives guidance to the equitable and sustainable management of the country’s water resources (Salman et al., 2006). Moreover, it provides for management and use of water resources that take into consideration “the basic human needs of present and future generations; redress for the results of past racial and gender discrimination; promotion of the efficient, sustainable, and beneficial use of water in the public interest; the need to protect aquatic ecosystems and their biological diversity; the facilitation of social and economic development; and the prevention of pollution and the degradation of water resources (NWA, Article. 2)” (Salman et al., 2006). The responsibility for implementing the principles of the NWA lies with national government through the minister of water and sanitation (Marjanovic, 2011).

It is worth noting that the South African NWA stipulates that one of its purposes is to ensure that its water resources are protected, used, developed, conserved, managed, and controlled in ways that take into account, among other factors, “meeting international obligations.” Salman (2006) points out that protection of the ecosystems of water resources is indeed a domestic legislative step to give effect to a state’s international obligations as is generally argued. However, not all water resources are shared with other states. Consequently, the South African requirement is perhaps the first time that national water legislation has referred to a state’s international obligations (Salman et al., 2006).

There are a number of role players in the water resource management framework some of which include; Catchment Management Agencies, Water Use Authorities, water boards, Water Service Authorities, science councils and research institutions, the Department of Water And Sanitation and water tribunal (Marjanovic, 2011). All of which, have a vested interest in the state of water resources, and will therefore invest funds into water resource monitoring. With as many stakeholders as seen above, there is a high chance of complexities, conflicts and uncertainty with regards to the roles and responsibilities, financial arrangements and regulations and enforcements.

As summarized under Section 4.2.4; The NWA envisaged that the Minister will “establish catchment management agency (CMA) for each water management area in the country. The NWA’s objective in creating this requirement is to ensure that the National Government delegates and decentralizes water resource management to the regional or catchment area and to involve local communities in the management of water resources.” (NWA, 1996); also states that it “provides that water users can create Water Users’ Associations (WUAs) (NWA, Section 91–98). These associations function as cooperative associations of local water users who wish to undertake water-related activities for their mutual benefit.” And lastly, it provides for the establishment of advisory committees for particular purposes. The function of these committees is to give the Minister advice on specified aspects of water resource management and use” (NWA, 1996). When narrowed down to water resource monitoring, the NWA authorizes the establishment of a number of institutions that participate in the regulation and management of water resources in South Africa (Salman *et al*., 2006).For instance; the National Water Monitoring Committee (NWMC) and the Integrated Regional Water Monitoring Committees (IRWMC) were formulated to ensure collaboration and coordination, and to provide guidance for the National Water Monitoring Programmes in terms of acquisition, management, dissemination and use of water information. In addition, its aim was to champion and support the

use of water information in decision-making. This meant that all stakeholders would need to be aligned and co-operate with one another to enable implementation.

In the Central African country of Cameroon, there are two statutes that apply to water resources law; “Statute No. 98-005 of 14 April 1998, which regulates all water resources except mineral waters and spring waters (Law 98-005); and Statute No. 79-10 of June 1979, amended by statute No. 90-16 of 10 August 1990, which regulates spring water (*eau de source*) and mineral water (*eauminerale*) (Law 79-10)” (Salman et al., 2006). While “Law 98-005 provides that water is a natural resource protected and managed by the State (Law 98-005, art. 2(1)).” Salman et al. observe that it does not explicitly address the issue of institutional arrangements. Compared to South Africa the laws of how water should be governed are still in the infantile stages, and virtually there is no information on the need for water resource monitoring as a whole, no strategies or policy to manage water resources except for the laws that provide for inspections of water installations and prospecting for and research of mineral and spring waters. The fact that the statutes do not “provide for river basin authorities; nor do they have explicit provisions on Water Users’ Associations or advisory committees” (Salman et al. 2006) shows that there is a serious problem in the governance of water resources as there are no structures in place to actually breathe life into legislation and implementation.

Similar to South Africa; the institutional arrangements in Brazil are such that the National Water Agency (ANA) a federal agency; implements the National Water Resources Policy and coordinates the national water resources management system as mandated by the federal executive branch according to Law No. 9984 (Salman et al. 2006).The executive branches of the States and Federal districts are responsible for implementing and operating the National Water Resources Management System, to award rights to use water and to regulate and monitor its uses

within the sphere of Federal Government competence, to create and manage the Water Resources Information System, and to promote the integration of water resource management with environmental management (NWRP, Article 29).

Brazilian River Basin Committees are very similar to the Catchment Management Agencies of South Africa in that they are composed of national government, States or Federal Districts in which the committees are located, the municipalities in which they are located, water users in their areas of action, and civil water resource agencies that have been active in the basin (NWRP, Article 39). River Basin Committees can request the creation of a Water Agency which is authorized by the National Council on water resources. Water agencies serve as executive secretariat for each committee (NWRP, Article 49). Water agencies' responsibilities are as follows; maintaining a roster of water users, collecting fees for water use, and managing the Water Resources Information System in their area of action, arranging as needed studies for the management of water resources in their area of action, and helping in the management of the River Basin Committee (NWRP, Article 44), in contrast to the WUAs of South Africa, whose primary purpose is to serve the mutual interests of its members, not to operate as a water management agency.

The NWRP provides for the creation of "civil water resource organizations" that include regional, local and sectoral associations of water users (NWRP, Article 47), however it does not describe the responsibilities or the required composition of these bodies. Unlike South Africa, where the WUAs and Advisory committees are legal bodies that can exercise whatever powers have been delegated to them by the Minister, Brazil's NWRP does not contain any provisions that specifically address the issue of advisory committee (Salman et al. 2006); it merely asserts that in order for the associations to participate in the National Water Resources Systems, they must be "legally constituted" (Salman et al., 2006). As

noted by Salman et al. (2006), the constitutions of Brazil and South Africa can be cited as examples for inclusion of references to innovative aspects of water resource issues. Brazil's constitution explicitly requires establishing a national water resources management system, while South Africa's constitution is the first constitution to make explicit reference to the right to water (Salman et al., 2006).

In comparison, Korea lacks an integrated and comprehensive law an integrated and comprehensive law that can deal with overall groundwater affairs according to Lee (2016). Lee (2016) argues that; at present, several laws and ministries are associated with the same groundwater resource but with their own distinct purposes and limited cooperation. When a groundwater quality issue is perceived by a ministry while conducting its inherent duties, it does not take appropriate measures if the ministry has only authority to deal with groundwater availability (i.e., water level decline or depletion). Therefore, Lee recommended that a comprehensive law is required to manage groundwater affairs in an integrated manner (Lee, 2016).

5.3 WATER RESOURCE MONITORING SUSTAINABILITY

The National Water Resource Strategy II describes climate variability as the natural variability in the climate in a particular region over time. South Africa in particular has highly variable climate with frequent droughts and floods and this is part of the natural climate cycle (NWRS2, 2013). Climate change on the other hand, refers to "long-term changes in the climate experienced in a particular region" (NWRS2, 2013). This means that climate change occurs naturally over long periods of time. And the NWRS2 however refers to climate change as a rapid change in the climate currently being experienced in the country (NWRS2, 2013).

The National Development Plan (NDP) recognizes climate change as a critical trend that will have a massive impact in the water arena. And in

turn have far reaching changes on the way people live and work in South Africa (NDP, 2012). It also states that; “South Africa is not only a contributor to greenhouse gas emissions – it is also particularly vulnerable to the effects of climate change on health, livelihoods, water and food, with a disproportionate impact on the poor, especially women and children. While adapting to these changes, industries and households have to reduce their negative impact on the environment” (NDP, 2012) and reflected on the need to “enhance the resilience of people and the economy to climate change.” .South Africa is known for low rainfall and high evaporation rates, while rainfall varies significantly from year to year and across the country (NWRS2, 2013) with an average annual rainfall of approximately 464 millimetres compared with a world average of 860 millimetres (WESSA, 2012). Climate change is expected to aggravate this variability in the form of floods and drought, and this will have substantial ecological, social and economic consequences (NWRS2, 2013).

As seen in Figure 4.6 (Section 4.1); 80 per cent of the participants observed drought, floods and high temperatures as weather patterns relating to climate change in South Africa and that these phenomena affect water resource quality and quantity. However, the current water resource monitoring system cannot provide data to support climate change claims and therefore cannot quantify the impact of climate change. For example this view was clearly stated in an article that appeared in the New Age newspaper where they pointed out the Minister of Water and Sanitation had declared Kwazulu Natal and Free State as drought disaster areas in November 2015 (See **Figure 4.5**). They went on to say that even farmers were concerned about the drought affecting maize production and ultimately raising food security concerns and economic concerns because exporting maize would quickly become expensive (New Age newspaper, November 2015). Sershen (2016) also noted that erratic weather patterns, particularly for rainfall, and, more recently, drought conditions in Kwazulu Natal and other parts of South Africa, necessitate a paradigm shift to ensure water supply is sustainable which requires a partnership between

water services authorities and the end-users. However, we cannot prepare for phenomena like drought and floods that we cannot measure over an extended period of time and what this conveys is the fact that water resource monitoring in South Africa is inefficient and is not conducted sustainably.

Another theme that emerged is the theme of urbanization and its effect on water resource quality and quantity and this was pointed out by Sershen (2016). According to Sershen social issues such as rapid urbanization and cultural perceptions of water re-use place pressure on water security and implementation of water facilities often do not adequately involve social and community structures (Sershen, 2016). Urbanization was discussed during interviews and focus group discussions and it was found that most participants believed that the increase in population in the urban centres is putting strain on the available water resources particularly in South Africa. As Sershen (2016) alluded; that rural to urban migration, as in other parts of Africa has also been a dramatic increase in urban dwellings mainly living in poorly or un-serviced slums which has had negative implications (in terms of quality and quantity) on natural resources such as river water and other water resources (Sershen, 2016; DWAF, 2005; Nyenje et al., 2010; UNICEF and WHO, 2015).

The most important impact of urbanization as observed by the study participants on Figure 4.2 was pollution of water resources which also has other compounding effects such as high water treatment costs as a result of declining water quality and public health issues. Surface water quality in many parts of the country is deteriorating from influx of domestic effluent (untreated wastewater) and industrial and sewage effluent (treated wastewater from sewage treatment works), runoff from agricultural lands and uncontrolled disposal of wastewater from informal settlements (Nyenje, 2010) and these mingling pollutants near urban areas makes identification and penalisation of many offenders extremely difficult (Sershen, 2012). The untreated wastewater is as a result of the high

hydraulic load into the Waste Water Treatment Works (WWTW) which cause the plants to function inefficiently and return waste into water resources. The views expressed by the participants seem to suggest the need for new infrastructure or improvements on the current aging infrastructure to augment capacity as the situation becomes more and more unmanageable, overall, participants' perceived urbanization to a negative result of economic development in the country.

For example within the study we discovered that 77 per cent of the respondents were of the view that (See Table 4.3 in Chapter 4) water resource monitoring programmes were not managed in a sustainable manner. Assessing the sustainability of water resource monitoring programmes and governance structures requires attention to both the monitoring of water resources and the human and institutional resources required to take and implementation decisions regarding water resource monitoring. As was discussed in Section 2.3, sustainable development is essentially about effective integration of social, economic and ecological aspects at all scales from local to global, where compromises and sacrifices are unavoidable (Kemp *et al*., 2005).

According to Bosselmann, governance for sustainability raises massive challenges due to the multi-dimensional perspective on institutions, however, continued "unsustainability" is not a practical solution (Bosselmann, 2008). For progress towards achieving sustainability, governance structures need to be established which can guide and co-ordinate positive input from a variety of actors on a wide number of issues at multiple levels with an awareness of their contexts and respect for uncertainty, conflict and complexities (Lockwood, 2009, Wiek and Larson, 2012). The concepts of conflict, uncertainty and complexity were introduced by Holling (1996) to help understand that human and ecological systems are dynamic; continuous change and surprise are inevitable. This change leads to uncertainty in natural resource and environmental planning and management (Holling, 1996; Mitchell, 2002).

According to Claassen (2013), complex systems exhibit the following: a large number of interacting elements, non-linear relationships between elements, system characteristics are emergent, the system integrates the past and present and this evolution is irreversible, the past is not a good predictor of the future and forecasting is difficult (Snowden and Boone, 2007). Rogers et al. (2000, p. 509) list 'dealing with uncertainty, complexity and change as given factors' as one of the required inputs for securing a nurturing institutional environment, whereas Pollard and Du Toit (2008) argue that management approaches of the past have failed to deal adequately with the challenges posed by complex and rapidly changing systems.

In view of the study participants' arguments on the sustainability of monitoring programmes, it follows that monitoring programmes are indeed a tool for sustainable management of water resources, however, the monitoring programmes are not being utilized to their full potential because of governance challenges in the monitoring space. This is further compounded by the challenges experienced due to climate change and urbanization – changing the water resource landscape that makes it difficult to manage water resources in a sustainable manner. For example within the study; urbanization, climate change, increased water use and water scarcity present a certain level of *complexity*, *uncertainty* and *conflict* in water resources monitoring and this analysis is presented on Table 5.1.

Table 5.1 Complexity, uncertainty and conflict in water resource monitoring**.**

Complexity	Political will and trust
	Many different stakeholders with interests in resources
	Fragmentation in monitoring governance
	Changing economic uses for water

Uncertainty	Limited predictive ability for flood and drought Uncertainty of future water supply due to climate change and urbanization Unclear roles and responsibilities among the stakeholders – who should monitor which resources and why?
Conflict	Competing human water demands versus nature needs - Loss of biodiversity due to urbanization Competing human demands and interests – who requires data and how will it be utilized?

Adapted from Maas (2011) Source: 63 Interviews and 5 focus group discussions.

Adding to the ***complexity*** of water resources, monitoring is the lack of commitment from leaders of government and institutions. Monitoring plans and strategies are drawn up but leadership does not prioritize them and this results in unsustainable monitoring programmes as resources; human and financial, are not channelled towards that need. Also, the many stakeholders in water resources monitoring are not communicating with each other and therefore cannot align, nor can they integrate their different programmes for maximum synergy. Urbanization and climate change has made it difficult to plan for and manage risk for future water supply and availability of water resources. Where water resource monitoring is not done, ***uncertainty*** arises in that floods and drought cannot be predicted. In addition, many of the stakeholders, particularly the DWS are unclear in terms of what their roles are in water resource monitoring which makes it difficult to share data and information when no one can tell who the regulator is and who the players are, as the legal implications are enormous.

In terms of ***conflict***; as urbanization increases, the water needs increase which presents competing interests ultimately resulting in conflict among stakeholders. With regards to monitoring, conflict arises when monitoring

programmes must be integrated, especially if one stakeholder monitors resources for business operations, and is not willing to share information with the DWS whose legal mandate is to monitor and also regulate other stakeholders. And the reason is, they seldom know how the data and/or information will be used. Lastly, with the increased incidence of urbanization, there is a loss of biodiversity, which puts human needs ahead of nature.

Integrated Water Resources Management (IWRM) is a vehicle through which equitable, economically sound and environmentally sustainable management can be realized (GWP, 2000). One of the requirements of IWRM is a shift in the current ways of working, especially the interactions between stakeholders, and the only way to make these changes depends on changes in governance (Rogers and Hall, 2003) and water resource monitoring is no exception. The study participants believed that no reform has taken place within water resource monitoring governance because even where monitoring is done, the principles of IWRM are not followed and the result is duplicated work, increased expenditure and non-representative data instead of improved data sharing and coordination of monitoring processes. During the focus group discussions, many participants mentioned that good decision making is based on having good data and information, all of which require commitment and adequate resources of all parties concerned.

In view of the above, it can be said that the monitoring governance environment is not conducive for all the policies, strategies and legislation to be implemented as they were intended. The challenges lie in the fragmented governance structures that are meant to encourage collaboration among stakeholders in water resource management. The participants speak of poor programme design, duplication of responsibilities, a lack of communication between stakeholders and ever changing political priorities as some of the reasons why the benefits of the IWRM concept have not been realized (see Section 3 in Chapter 4). Even

with the well-meaning legislation for water resources in South Africa, National Water Act (Chapter 14), Water Services Act (10) and National Water Resources Strategy 2 (Chapter 13); government in particular are finding it difficult to regulate other stakeholders. Clear roles and responsibilities are important in IWRM. One needs to understand what they need to do, how they need to execute it, integrate and why they are fulfilling that responsibility. This confusion leads to a duplication of efforts and waste of financial resources. Every new administration brings new perspectives on priorities and funds thereof and if monitoring is not seen as an integral part of managing water resources, the result is disastrous as many participants have alluded to.

5.4 WATER RESOURCE MONITORING GOVERNANCE

One of the key things that have come up in this research is the issue around inefficiencies in the water resource monitoring management; this has been reflected for example in Section 4.3 in Chapter 4. However, what is important here is to really understand why the structures in water resource monitoring in South Africa are not being implemented. Moreover, there are quite a number of factors being advanced here. And the first one that can be discussed here is the participants' knowledge of legislation around water resource monitoring and understanding of their respective mandates and secondly, water sector leadership and regulation.

The NWA was the most cited piece of legislation which illustrated an understanding of the mandate with regard to water resources and conservation thereof. However, some of the institutions mandated with water resource monitoring responsibility were said to be non-compliant. Municipalities were the institutions recognized to be failing to monitor water resources as they should, moreover, co-operative governance was said to prevent DWS from prosecuting these institutions for non-compliance in water quality and quantity standards. Regulation is an important element of Integrated Water Resource Management, one which

will gain increasing importance as the stress on South Africa's limited resources increases (DWA, 2010). The focal point of water resources regulation is the efficient, sustainable and equitable use of a limited natural resource. Water use licensing is an example of a water resource regulatory instrument; however water theft and deteriorating water quality levels show that current regulatory practices are failing to address the water resource challenges (DWA, 2010).

Governance regulation involves the institutional structures for water resource management in the form of Catchment Management Agencies and Water Use Authorities (DWA, 2010). The regulatory instruments for Compliance Monitoring and Enforcement are issuing directives, and the ability to take action and reclaim costs from users of the water resource (DWA, 2010). Internationally, water resource regulation is usually dealt with by environmental departments or agencies while water services regulation is often dealt with by an independent regulator, or a range of departments often at local or provincial/state level. The difference with South Africa is that water services and water resources regulation is located in one department, the Department of Water and Sanitation (DWA, 2010). In Ghana for example; the Public Entities Regulatory Commission is responsible for economic regulation of urban water supply and sanitation, while the Water Resources Commission regulates water resources (DWA, 2010). In the same way, Zambia's National Water Supply and Sanitation Council (NWASCO) regulates urban water supply and sanitation service provision, while water resources regulation falls under the Department of Energy and Water Development (DWA, 2010).

One of the key things that have come up in this research is the issue around effective water sector leadership. The findings indicate that DWS is not an effective water sector leader due to rapid change of political leaders which destabilizes DWS as the department has a massive impact on service delivery. Moreover, the lack of prioritization of water resource monitoring needs shows a lack of understanding of DWS core mandate.

Lastly, there are good strategies that are not being implemented. A further complication rises when co-operative governance comes into play as cases brought to the water tribunal pertaining to water resource management regulation have been lost by the DWS “on administrative grounds rather than on substantive policy grounds” as mentioned by Musiyarira (2011). This indicates good policy framework but a lack of implementation i.e. administrative functions resulting in self-regulation. Musiyarira (2011) also goes on to suggest that there are a number of reasons for this weakness some of which are; resource deficiencies, inappropriate institutional arrangements currently in place.

There has always been an issue about regulation and if it is a function of the DWS or needs to be independently operational outside of the DWS. This has brought about opportunity for preliminary institutional reforms in water resources regulation in the National Water Resources Strategy through a consultative process that was envisioned to potentially clear up some of the confusion with regards to roles and responsibilities and implementation of the strategy (Saleth and Dinar, 2005). Basically, the water sector of South Africa has no definite regulator. What lags behind are regulatory and governance reforms; these have taken much more time to bear fruit (Karar et al., 2011). For instance, effective regulation in the whole water value chain requires building of water institutions/entities that would challenge established vested interests (Ruiters, 2015).

“Governance improvements, particularly in State-Owned Enterprises (SOEs), institutional competence, capacity and performance are important determinants of water infrastructure provision and management in South Africa” (Saleth and Dinar, 2005; World Bank, 2010; Karar et al., 2011; Van Koppen and Schreiner, 2104). This seems obvious, but systematic analysis has been lacking on the nature and extent of the links between stronger institutions and better outcomes; specifically, broader access, higher service quality, and financially efficient services. There has also been new thinking about the options for water institutional reform and

governance in South Africa on how large water infrastructure projects will be developed, managed, operated and maintained (RSA, 1997a, 1997b; DWAF, 2004, 2007; DWA, 2013a; RSA, 1998; Ruiters, 2013).

5.5 WATER RESOURCE MONITORING CHALLENGES

One of the key things that have come up in this research is the issue around challenges in the water resource monitoring. This has been reflected for example in Section 4.4 in Chapter 4. There are quite a number of factors being advanced here, for example; lack of financial and human resources, lack of specified roles and responsibilities, poor governance structures for water monitoring, ineffective stakeholder engagement and inefficient data management.

I. Lack of financial resources

The field data from the interviews, focus group discussions and questionnaires administered suggest that a lack of financial resources is a huge impediment to development; socially, environmentally and economically in the water sector. Those involved in water resource monitoring cannot purchase monitoring equipment and personal protective clothing, and cannot access monitoring sites because of logistical constraints. This means that fewer sites are monitored or maintained and as a result, decision-makers cannot get the full picture of what is really happening i.e. is water resource quality and quantity deteriorating or improving? This shows that even if there are strategies or plans designed to mitigate deterioration water resources, they may not be implemented effectively. It can be said that the framework under which the funding is allocated for water resource monitoring is highly flawed in that supply chain management measures or red tape are making it more and more difficult to gain access to funds.

Water resource monitoring is undoubtedly a very expensive exercise and the lack of financial resources is experienced in many countries in the

world. For example, in the Kenya National Water Development Report (2006), financial resources were identified as a limiting factor to sustainable development where minimum appreciation and understanding of the role water in an economy has contributed to poor funding for water resources management and development and as a result, institutions responsible for implementing water resources management have weakened (UN, 2006). Funding of research in the Kenyan water sector is tough because the government has to decide if resources are channelled to provisions of resources or research, which may not have a direct benefit or impact on the ground in the short term, particularly where there are limited resources (UN, 2006).

On the other side of the spectrum; Bigas (2012) argues that “money alone will not be enough to solve all the problems in the water sector.” He goes on to say that in many countries, major public institutions do not have the capacity to address water issues even if sufficient funding were made available. To prevent water quality and availability issues from delaying economic or social progress and exacerbating conflict, help from other countries as well as financing are required (Bigas, 2012) Furthermore, development cooperation also needs to be encouraged in order to ensure that it includes all economic flows, and not just direct aid (Bigas, 2012).Theft and vandalism of monitoring infrastructure is another challenge in water resource monitoring. This in turn results in the expensive exercise of replacing monitoring equipment and thereby absorbing into the resource monitoring budget and this was mentioned quite a few times in the focus group discussions and some face to face interviews. And this indicates that it is a constraint that needs to be addressed in order to have a sustainable water resource monitoring network.

In 2011, The South African Institute for Civil Engineering (SAICE) and the Council for Scientific and Industrial Research (CSIR) reported that South Africa’s bulk water infrastructure will soon require upgrade or replacement

as a consequence of reaching the end of its lifespan (SAICE, 2011). Similarly, in the study by Ruiters (2015) it is acknowledged that emerging infrastructure backlog and deficient capability warrant immediate attention if South Africa is to build on and secure its already impressive record of sustained economic growth, competitiveness and productivity gains through appropriate institutional and governance models (Ruiters, 2015). Replacement of aging infrastructure which is currently managed by DWS is estimated at 160 billion rands to meet increasing water demand over the next 20 years (DWA, 2011a, 2013a, and 2013b). Ruiters (2015) also alludes to the fact that a combination of governance and institutional models or frameworks are required to address the funding and financing of the water infrastructure problem, however, current water institutions are fragmented and in need of serious review and reconfiguration.. Furthermore, how those models and/or frameworks should be combined depends on the water sector governance structures, financial markets, funding and finance pool, and the political climate among other factors (Ruiter, 2015). For example, if the country prioritizes water infrastructure as an essential part of the nation's capital infrastructure, then the above models should be favourable alternatives for obtaining capital financing (Ruiters, 2015).

To gain more insight into the challenge of funding in water resource monitoring, participants were asked if the budget was sufficient to monitor the quality and quantity of the country's water resources.

For example within the study we discovered that 53 per cent of the respondents were of the view that (See Figure 4.11 in Chapter 4) the budget is not adequate for water resource monitoring. The field data suggests that water resource monitoring is not prioritized as it should be, moreover; when cost containment measures are implemented, the water resource monitoring budget is the first to be cut. Meanwhile, climate change impacts like flooding are felt first by the monitoring equipment which will need to be replaced at a more frequent rate which in turn

requires a bigger budget. The participants that cited that the budget is indeed adequate stated that the real challenge experienced is the failure to utilize the budget allocated. The field data suggests that failure to utilize budget allocated is a direct impact of supply chain restrictions when it comes to procuring goods and services, therefore funds cannot be used in the financial year it was reserved for.

The findings suggest that budget constraints are inter-relational including; human resource shortages, supply chain restrictions and political undercurrents. To draw any conclusion, it would be very useful to understand that the international industry standard budget is for an information intensive organisation. One needs to compare what should be spent on water resource monitoring, taking into account data collection, analysis and information dissemination.

In the 2004/05 financial year, the total budget for water resource monitoring in South Africa was set at approximately 192 million Rand (DWAF, 2004). And the required growth for 2005/06 financial year was forecasted to grow by 38 million Rand, which in total would add up to 230 million Rand. However, the water resource monitoring budget allocated for 2012/13 was 191 million Rand when the actual needed was 247 million Rand (DWA, 2013) and interestingly the funds required for best practice for the existing monitoring network was around 315 million Rand. This clearly confirms that water resource monitoring budgets are grossly underfunded. If we compare the South African water resource monitoring budget to the Canadian water resource monitoring budget, we find that for the fiscal years 2006/07 to 2009/10 the budget has been stable at 35 million Canadian dollars (350 million South African Rand) which represents 3.1 per cent of Environment Canada's overall budget (Vaughan, 2010). The water resource monitoring costs of first world countries like Canada may be on par with international standards and stable due to the fact that they share monitoring responsibilities by having arrangements with provinces, territories and private sector thereby sharing

cost of the monitoring, i.e. integration of monitoring programmes. In total, 13.9 million dollars was cost-recovered through these arrangements which allow for investments in monitoring technologies and increased budget where needed (Vaughan, 2010).

As stated above, the South African water monitoring budget is underfunded and the unfortunate result of under-budgeting is poor service delivery. The field data suggests that this stems from poor performance and inability to meet quarterly and annual targets as a result of receiving funds too late or not at all to carry out the duties of water resource monitoring as seen in Figure 4.17.

Competing demands within the Department of Water and Sanitation (DWS) for example; provision of sanitation services and potable water for all is prioritized which results in reduced allocation of funds into water resource monitoring which leads to poor performance and ultimately manifests as poor service delivery as illustrated on Figure 4.17

According to Chapter 5 of the NWA, a number of instruments are suggested to the Minister of Water and Sanitation to enable financing “the provision of water management services and the implementation of strategies designed to protect and conserve water and ensure the beneficial use of water” (NWA, Sections 56–62). The charges for the use of water paid by water management institutions can be used to fund the management of water resources and development of water infrastructure (Salman et al., 2006). A comparative study done by Salman et al. (2006), shows that the government raises revenues through water charges, which is a tricky issue in itself because culturally, water is perceived as a “God-given gift” for which no charges should apply. The end result is that insufficient revenue is generated and further investment into channels like water resource monitoring becomes minimal compared to competing demands like sanitation.

The unfortunate result of under-budgeting is poor service delivery that stems from poor performance and inability to meet quarterly and annual targets as the people who are actually doing their job receive the money too late if at all as seen on Figure 5.1.

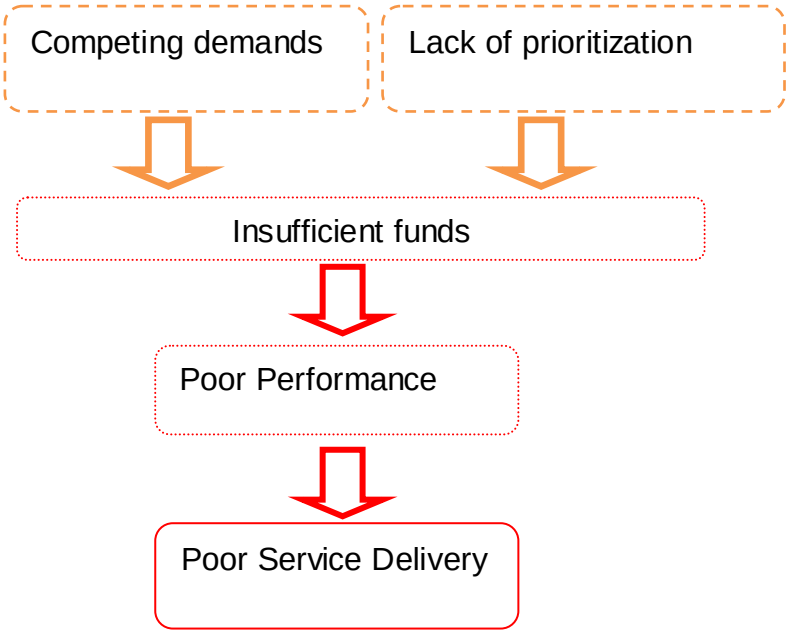

Figure 5.1 Relationship between under-budgeting and poor service delivery.

Competing demands within the DWS for example; provision of sanitation services and the lack of prioritization of water resource monitoring results in insufficient funds for water resource monitoring. Water resource monitoring includes equipment (laboratory and field work) purchases, private observers and technicians compensation, ongoing training and logistics for example; which leads to poor performance and ultimately manifests as poor service delivery as illustrated on Figure 5.1.

According to Chapter 5 of the NWA, a number of instruments are suggested to the Minister of Water and Sanitation to enable financing “the provision of water management services and the implementation of strategies designed to protect and conserve water and ensure the beneficial use of water” (NWA, secs. 56–62). The charges for the use of

water paid by water management institutions, can be used to fund the management of water resources and development of water infrastructure (Salman et al., 2006).

II. Lack of human resources and/or skilled personnel

The evidence in Section 4.4 in Chapter Four on water resource monitoring challenges indicates that there is a serious lack of qualified human resources to carry out monitoring responsibilities, be it data collection, analysis or dissemination. As some participants pointed out; many of the highly skilled labourers are seeking greener pastures outside of South Africa. The reasons for this could be; they are not receiving adequate compensation for their skills or the environment (institutional framework) may not be conducive to implement the policies or reforms they are mandated to achieve. Some of the staff members are “up-skilled” within the organization; however they tend to leave for reasons mentioned above. And it would seem that the DWS has no strategy to retain highly skilled staff. The professionals that remain within the DWS, tell a sombre story about having to fulfil all the monitoring needs with limited human resources, which is near impossible.

The lack of human resources and qualified staff is also an issue in many countries. For example, in India the major constraints when implementing their bio-monitoring programmes are a lack of skills (taxonomic), a serious lack of manpower and a general lack of resources (financial) (Trivedi *et al.* 2008). It is well known that the most important problem and policy challenge is one of governance, not a technical one. Effective water resource management at local, regional and national level can be achieved if an institutional structure exists. The general consensus in the South African water sector is that water resource management functions should be delegated to the lowest technically competent level. Therefore training and education programmes at local or lowest level are a requirement to realize the goal of optimal management of water resources in the country.

The field data indicates that DWS has neither retention strategy nor succession plan for their current staff complement and that OSD (Occupation Specific Dispensation) packages and the Learning Academy were one of the few ways in which the DWS was striving to promote competence, attract and retain water resource monitoring technical staff. Similarly, Sershen (2016) stated that there is a failure to translate research into policy and practice, and a lack of skills in leadership and technical positions. Also loss of knowledge and expertise by movement of skills into the private sector or through emigration is a problem (Sershen, 2016). The findings also indicated that 57 per cent of the participants were under the age of 35, holding positions in middle management in the water sector. Only 43 per cent were over the age of 50 in senior management positions. This indicates that the bulk of the staff complement is nearing retirement and will soon leave Department of Water and Sanitation with all their institutional knowledge. Institutional memory is of paramount importance as it assists in planning for the future needs of the country and identification of opportunities. While there is a direct relationship between number of years experience in DWS and mentorship; it is important to recognize that only four per cent of the training carried out by the DWS is mentorship or mentorship programmes. This is an alarming statistic considering the older generation will retire and leave with a wealth of knowledge that could have been imparted onto the younger generation.

Musiyarira (2011) citing Marjanovic et al. (2011) observed that; “A key challenge is that regulatory expertise and skills are not readily available in the country and DWA is not likely to easily attract and/or retain the appropriate skills. In this regard, learning from the experience of other departments, such as DEA, and developing a formal programme to develop the necessary skills will be critical to the success of water resources regulation in the country.” And ultimately this has a profound and material impact on regulatory credibility and effectiveness of the DWS. Musiyarira (2011) also stated that the establishment of CMAs should be fast-tracked to assist the clarification of roles and responsibilities and also

to increase regulatory capacity and avoidance of player/referee scenario where possible.

III. Poor governance structure

One of the things that have been identified within the study in Chapter 4 was the aspect of poor governance. The structures that have been put in place are inefficient in any of the regions in South Africa. One of the things that was identified through the discussion with the respondents was the importance of governance. Governance was defined previously as the structures, processes and actors, their interactions and how they facilitate and influence decisions affecting water resource management in the context of monitoring. The relationship between water governance and water resource monitoring is that both set out to manage water resources in a sustainable manner to achieve the goals of development. One needs to monitor water resources in order to make decisions collectively and effectively with the relevant stakeholders, and this requires functional governance structures that enable dialogue between stakeholders about the issues of water.

In the context of South Africa, integration and reform within the water sector is needed because in the absence of good governance structures, we can argue that implementation of programmes and structures aimed at water resource monitoring will not take place. For example, according to the UNDP (2013) it is argued that an important part of good governance is managing public resources and guaranteeing the realization of human rights in a manner free from corruption and abuse and with due regard for the law and the extent to which it delivers on the promise of human rights, civil, cultural, economic, political and social rights (UNDP, 2013). But in the context of our findings it appears that governance itself is weak and has a number of challenges and in this context it can be said that it is only through institutional structures where effective water resource management at local, regional and national level can be achieved. And in South Africa, the current structure is not fit for that purpose. The general

consensus in the South African water sector is that water resource management functions should be delegated to the lowest technically competent level. Therefore a training and education programme at local or lowest level is a requirement to realize the goal of optimal management of water resources in the country.

The lack of institutional clarity as mentioned above is an indication of government failure as this almost always results in lack of accountability when it comes to service delivery; as a result, citizens have lost trust in their government's ability to manage water resources in a sustainable manner. Under this theme, the concept of *accountability* or the lack thereof, came up a few times during focus group discussions and key informant interviews. The general feeling is that, no one wants to take responsibility for water resource monitoring, moreover, no one wants to report on the status of water resources. The reason for this may be that there is insufficient data to analysis and give a clear picture of the state of water resources because water resources have not been monitored due to lack of resources (financial and/or human).

Politics will always have an influence on how water resources are managed. Administration is changed every five years, and the change brings about new appointments, new leaders with different priorities. Sershen (conducted facilitated focus group discussions centred on water security and governance: challenges and advances. The major challenges found were lack of both skills and political will in government, a need to restore trust in government intention and capability to deliver water-related services, and a failure to up-scale existing water re-use technology. (Sershen et al., 2016)

The lack of specified roles and responsibilities was another theme that emerged from the interviews and focus group discussions. Roles and responsibilities are important because then each organization will know exactly what they are doing and how far they can go. The findings show

that lack of accountability, politics/political will, unclear roles and responsibilities are factors that contribute to poor governance in water resource monitoring. Compounding the effects of these factors is the fact that there are many actors involved in governance of water resources with different needs and priorities. Poor water monitoring governance stems from a lack of awareness and/or understanding of how water resources can be managed through monitoring.

According to Toonen (2011), “Governance is about establishing the appropriate means and setting limits and constraints within which operational action in terms of water management can take place.” Where limits and constraints are not set, fragmentation occurs and results in unsustainable practice. One example is that of hiring people who are not qualified to do the job because of the corrupt nature of politics as alluded by study participants in Section 4.5. On the other hand; Ongley (1997) states that the old model where government does everything and pays for everything is being replaced by market forces in many countries. Meaning that “some governments, especially in developed countries, are reducing their direct participation in monitoring and enforcement, and are concerned primarily with setting and enforcing rules and standards” (Ongley, 1997). He goes on to say that developing countries should be doing the same as “market forces will produce more efficient laboratories and decrease the need for government expenditures” because under market economic conditions, there is greater efficiency and less cost to government if industrial monitoring is carried out by industry with data reported to government agencies (Ongley, 1997).

It must be noted that the IWRM was formulated for the purpose of governing water resources. This assertion, as observed by Lubell and Edelenbos (2013) is based on IWRM being a response to several sources of fragmentation in water governance systems namely; functional, social and institutional. Of particular importance for this study is institutional fragmentation that occurs when different water management authorities

fail to coordinate within and across levels of government. Lubell and Teisman is of the perspective that constant pressure needs to be applied to bring the different fragmented pieces together and organize integration and interconnection. Thus, effective water resource management should be seen as a function of facilitated cooperation, joint responsibility and integration within governance systems (Edelenbos and Teisman 2011).

Many of these problems stem from a lack of understanding of roles and responsibilities in the water sector across the globe and failing to prioritize water resource management as a way to achieve the goals we set out for ourselves. We prioritize poverty reduction but the interesting thing is, it is the poor that lack access to this basic service and/or need. Water issues are often complex and governments battle to integrate social, economic and environmental aspects. This is because the government itself cannot collaborate effectively at the national, regional and local levels. Collaboration between stakeholders external to government and government has been minimal if not strained (UN, 2006), while decision making becomes more difficult when water issues need to be resolved at national and committee level. The lack of institutional clarity as mentioned above is an indication of government failure as this almost always results in lack of accountability when it comes to service delivery; as a result, citizens have lost trust in their government's ability to manage water resources in a sustainable manner.

IV. Ineffective stakeholder engagement – 'working in silos'

Ineffective stakeholder engagement was cited as one of the challenges experienced in water resource monitoring. The findings suggest that 'silo mentality' in water resource monitoring is contributing to the current dire state of affairs. The result of this is a lack of communication among stakeholders and ultimately duplicating responsibilities and wasting money. An aspect of stakeholder engagement involves collaborative planning or shared decision making. According to Booher and Innes

(2010) collaboration is a process in which “individuals representing differing interests engage in long-term, face-to-face dialog, seeking agreement on strategy, plans, policies, or actions.” Wondollecck and Yaffee (2002) go on to say that Collaborative Planning (CP) is built on the idea that the individuals and groups affected by a plan are the best candidates to be empowered to jointly work together to create the plan. Participants in CP processes collaborate by pooling their resources in order to solve a set of problems which cannot be solved individually (Wondolleck and Yaffee, 2000). In the context of this study, collaboration is used in water resource management to address planning policy or management issues that affect various interest groups in society. These are representatives from private companies, catchment management agencies, government and the community who have a vested interest in water resources (Margerum, 2002).

There are many reasons why decisions cannot be made collectively by stakeholders. Gunton and Day (2003) discuss five challenges associated with collaborative planning; namely; unequal power relations, unequal stakeholder representation, logistical challenges, perverse outcomes of consensus rules and effectiveness in dealing with fundamental value differences. Lubell (2013) argues that a lack of meaningful participation is not entirely the fault of legal institutions or government authorities. However, Lubell (2013) citing Claassen (2013) argues that “South Africa has sufficient legal instruments that promote interactive processes and stakeholder participation in the management of natural resources, but lacks a high enough level of civic competency, experiences and innovation to take advantage of participation opportunities.” *Unequal power relations* is where more powerful stakeholders may avoid or undermine collaborative planning, using their superior power and resources to delay processes or pursue alternative means to achieve their objectives (Gunton and Day, 2003). This is seen in the form of DWS being the player and the referee with regards to water resource monitoring. DWS is mandated to monitor water resources however; they (DWS) are also the regulator of

other institutions monitoring water resources. On the other hand, weaker stakeholders who are frustrated with the process may withdraw, reducing the likelihood of a mutually beneficial outcome. This is evident in the reluctance of stakeholders, particularly, private companies and municipalities to participate in the various platforms, be it catchment management forums or integrated water monitoring committees in Gauteng region and across most regions in South Africa which brings about *unequal stakeholder representation*, where the little representation of interests of smaller organizations leads to exclusion of other public interests not represented by organized groups. Another dimension is the *logistical challenges* that are involved in collaborative processes. Organizing a large group of stakeholders to come together over a successive number of meetings as is the case with the Gauteng Integrated Water Monitoring Committee Meetings, can consume substantial financial and administrative resources, especially when a committee meeting needs to be postponed so that there can be adequate representation. The lack of stakeholder engagement leads to a lack of *monitoring programme integration.*

The findings show that it is quite difficult to integrate monitoring programmes among stakeholders. Part of the problem is that for example; Water Boards cannot share data or information generated from their data in the Regional Integrated Water Monitoring Committee meetings run by DWS officials because they are also regulated by DWS and they would not want to expose themselves and risk being labelled as non-compliant. Another aspect of collaborative planning that can be applied here, is that of *effectiveness in dealing with fundamental value differences* (Gunton and Day, 2003). Water boards are monitoring water resources simply because they have business interests and are being regulated by DWS. The same DWS desperately aims to integrate monitoring programmes with external stakeholders to achieve maximum synergy and save on resource monitoring. So the question is, can the DWS really rely on the data

provided by external stakeholders and vice versa. These widely incongruent values make collaborative planning difficult.

In Cameroon for example, Ako (2010) examined the recent efforts to implement IWRM by examining the institutional framework (Ako, 2010). It was found that reforms such as public participation at local council levels, recognition of water as both an economic and a social good, putting IWRM within the larger context of Integrated Natural Resource Management (INRM) will improve IWRM in Cameroon (Ako, 2010). In Korea for example; Lee et al. (2016) argues that ministries and affiliated agencies for groundwater monitoring lack communication with each other. Lee et al. (2016) went on to say "each ministry develops a Monitoring Network for its own purposes almost independently, without sharing enough information with other ministries as to the well locations, well specifications, and monitoring devices." Often monitoring wells, each of which is operated by a different ministry, happen to be located very close to each other and annual reports published by different ministries contain redundant data. This current practice raises a sustainability issue for the overall monitoring system. Lee et al. recommended that holistic approaches among different ministries and agencies are required to secure the groundwater resources of the country (Lee et al., 2016). Some of these approaches include; active participation and feedback from the public, unified manuals for the installation of monitoring wells and information sharing between ministries and affiliated ministries (Lee et al., 2016). South Africa could implement at least one of them for example; information sharing among departments and affiliated agencies can occur provided they attend the Integrated Water Monitoring Committees and actively participate. Sershen (2016) argues that; if there is insufficient engagement with external stakeholders, it will be difficult to regulate all the water users' consumption and compliance to water use license conditions.

Within the South African context, research has established that there are many channels used to communicate water resource monitoring

information but the most utilized is websites and the least utilized is personal contact. While it is easier to convey information via the internet, which poses a security threat; the question that arises is; is the data and/or information safe for public consumption? The findings suggest that data and/or information is actually stored on unapproved software and excel worksheets, and no one else would have access if the computer crashes. In the Korean context, most of the monitoring data is available to the public through internet websites and these networks have provided scientific data for designing groundwater management plans and contributed to securing the groundwater resource particularly for recent prolonged drought seasons (Lee et al. (2016).

V. Inefficient data management

Monitoring data quality is a problem in many developing countries., where challenges like obtaining pure reagents, or certified reagents, site conditions and air handling systems to name a few contribute to unreliable data (Ongley, 1997). Of particular importance and absolute necessity is an accreditation programme that establishes common performance criteria for all laboratories responsible for water quality data used by government and those private laboratories that serve government needs (Ongley, 1997). Institutional inefficiency is one factor that has legal and regulatory implications, especially where the regulatory framework imposes rigidity and prevents the use of more cost-effective field and analytical methods. “However, the greatest inefficiency tends to lie in the assumption that conventional water quality programmes produce data that can be used to make managerial decisions on pollution control, water resources planning and related investment decisions. The fact is that, such programmes are designed mainly for descriptive rather than prescriptive purposes, with the result that nations tend to spend much money producing data that are not closely linked to decision-making and, not infrequently, not used at all!” (Ongley, 1997)

The findings show that there is a shortage of accredited laboratories for sample analysis. This results in gaps in data that would otherwise produce trends to help make sound decisions concerning water resources. Also, it would seem that there is a lack of investment in laboratories and their accreditation. It comes down to the fact that government does not prioritize monitoring of water resources and therefore do not channel funds where they are needed. The USA, Canada and many European countries have developed national data standards through programmes of quality assurance and laboratory accreditation. “National standards impose a strict regimen on all aspects of laboratory operations and, in some cases, field operations, so as to ensure the reliability of the final data products. The present situation in some countries where there is devolution of decision-making authority to local levels, has been the loss of national data standards, which is catastrophic for developing countries that require reliable data for evaluating and deciding upon investment alternatives for remediation and/or development” (Ongley, 1997). In the Korean context, the groundwater monitoring network utilizes its own well-specifications, probes, and telecommunication protocols with minimal communication with other networks. Duplicate installations of monitoring wells are not uncommon among different networks and thus it takes an unnecessarily long time to convert each network data to make them comparable with other network data, which makes the current groundwater monitoring network unsustainable (Lee et al., 2016). Lee et al. (2016) also suggests that unified manuals are necessary for the installation of monitoring wells.

5.6 SUMMARY

The three major challenges were identified as follows;

I. skills gap/lack of technical capacity within the water sector,
II. knowledge loss (experts leaving country or sector),
III. silo thinking and planning.

All of these were found in this study as well as in Sershen's 2016 study. The underlying factor in the following major challenges listed above stems from rapid change in water management institutions.

This is a direct impact of new administration every five years in South Africa. It is felt in the form of change in minister of the DWS, who in turn, shuffles the executives of the department according to the political priorities. This is illustrated in the figure below (Figure 5.2).

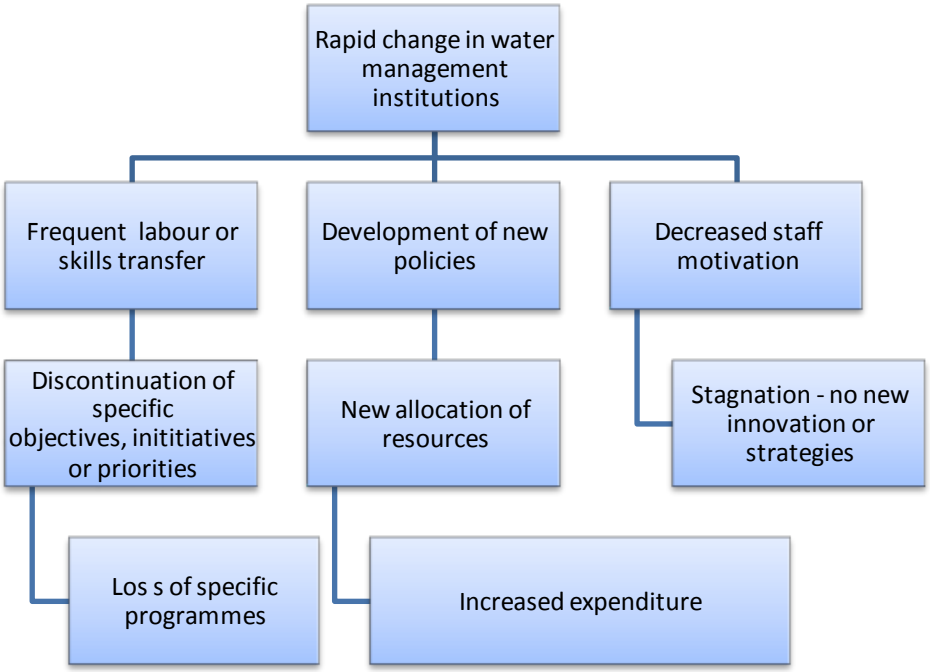

Figure 5.2 Summary of challenges in water resource monitoring.

I. Development of new policies

The rapid changes result in the development of new policies to align with the new priorities. Funds are then channelled or allocated towards this need and away from where it is really required like water resource monitoring etc. which ultimately results in increased expenditure overall.

II. Decreased workers motivation

Another aspect of rapid institutional changes is a sharp decrease in staff motivation. Staff is uncertain where they will work next, their projects for

the past few years are left uncompleted, and the fruits of their labour are never really realized. This results in stagnation where no new strategies are drafted and there is no growth altogether.

III. Frequent labour or skills transfer

This aspect of rapid institutional change is frustrating because, when staff is moved, there will be discontinuation of projects/priorities and initiatives, which in turn causes loss of programmes and ultimately results in decreased motivation for staff to be productive and contribute in a meaningful manner. The findings suggest that there is a lack of skilled human resources to carry out water monitoring responsibilities, implement policies and evaluate if the policies are being implemented. Moreover, there is general lack of political understanding for monitoring needs hence there is a lack of prioritization for water resource monitoring.

The key issues raised here are the water resource monitoring challenges we are contending with as a country such as lack of infrastructure, financial and human resources and sustainable water resource management framework. The findings reveal that there are discrepancies in policy and legislation set out and the implementation thereof. This is seen in the form of weak water resource management functions of the institutions responsible for water resource monitoring and the failure to implement institutional reforms set out in recent years.

5.7 CONCLUSION

The purpose of the study was to analyse and describe the factors that play a role in institutional fragmentation that impede the formation of a comprehensive management system of water resources monitoring in South Africa. The analysis of the data obtained revealed that there are five major challenges that account for non-existence of water resource monitoring management system. These are; lack of financial resources, lack of human resources and/or skilled personnel, poor governance

structure, ineffective stakeholder engagement and inefficient data management. The above water institutions and governance challenges are resulting in inadequate investments and millions of South Africans not having access to basic water and sanitation services (Ruiters, 2015).

Ongley (1997) is of the notion that managing large organizations like government departments can be very difficult when introducing change, as "senior management often resort to budget solutions (reduced budget equals reduced number of monitoring stations) rather than to a serious examination of how modern monitoring technologies, regulations and institutional structures can introduce greater efficiencies." He goes on to say that it is essential that commitment be demonstrated at the most senior levels of an organization. An example of commitment is in the realm of training (Ongley, 1997). It is important to note that these challenges are interlinked; they produce knock-on effects on each other. Therefore the elimination or mitigation of one of the challenges may help solve another. In conclusion, it could be argued that these challenges can be used as entry points towards formulating an effective water resource monitoring management system. As the study also provides some insight into the complexities that bring about the challenges, it may help point towards solutions and new perspectives.

The study findings indicated that there is a growing demand for policy reform to address these challenges and close the gaps and limit the rapid change in water management institutions. In the case of this study, it appears that the power of politics coupled with inefficiency of government in the local and national contexts undermine the sustainable development of water resource monitoring. Achieving the goals of a sustainable water resource monitoring in the context of South Africa would require changing the institutional structures, which in turn influence the ways of working.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter aims to bring together the key findings and the key lessons learnt about water resource monitoring in South Africa. This section is divided into three sections. First, it provides an analysis of how the information presented in this research answers the research questions and the challenges experienced by experts in the water resource monitoring fraternity. Secondly, it considers recommendations and lastly, future research focus areas and some initiatives that can be implemented and the overall contribution of this research to water resource monitoring are discussed.

6.2 RECAPPING THE KEY STUDY FINDINGS

One of the things the study was interested in was to understand whether monitoring programmes could be used as a tool for sustainable water resource monitoring in South Africa and a number of views were obtained. It was found that climate change and urbanization have a detrimental effect on water resources due to drought and flood events, eutrophication, illegal water connections, loss of biodiversity and pollution effects on water resources of South Africa. All these bring about a certain level of uncertainty, complexity and conflict as seen in Chapter 5, Section 5.2. as the landscape of water resources changes continuously.

However, the impact of these challenges cannot be measured as current monitoring systems are not functioning optimally which has an impact on sustainable water services delivery and food security in South Africa. The results indicate that monitoring programmes are indeed tools with which sustainable management of water resources can be achieved. However, the monitoring programmes are not being utilized to their full potential due

to governance challenges in the monitoring systems. It would be helpful to build socially resilient and adaptive responses to social climate and general environmental change before it occur (Siebrits, 2014). It was also found that sustainability of monitoring programmes relies on human and economic investment and it can be said that lack of skilled personnel and lack of funding for monitoring equipment and aging infrastructure are the leading challenges in this regard.

It was also found that South Africa has sound legislation that guides water resource monitoring. The legislative framework consists of the Constitution of South Africa (Act 108 of 1996); National Water Policy White Paper (1997), National Water Act 36 of 1998 and National Water Resource Strategy (2004, 2013) which are readily available. As Ruiters (2015) stated that one of the critical elements in ensuring that policy and mitigation strategies are followed is to share and disseminate knowledge timeously and meaningfully. The results suggest that most the participants involved in water resource monitoring activities have a working knowledge of legislation and most are fulfilling their monitoring responsibilities under immense pressure due to lack of competent work force. As highlighted in Chapter 5, Section 5.2, it was suggested that DWS is neither an effective water sector leader nor an effective water sector regulator. This is due to conflicting roles that DWS plays in the water sector, which in turn will ultimately confound the roles and responsibilities of its employees. Other challenges include corruption with the DWS and co-operative governance issues that result in no action taken against those not fulfilling their water monitoring responsibilities. In conclusion, the current regulatory environment in the water sector is not conducive for DWS to lead the water resource monitoring system effectively.

One of the other things the study was interested in was to understand the challenges in water resource monitoring in South Africa and a number of views were obtained. It was found that the four major challenges that impede the formation of a comprehensive water resources management

system were; lack of financial resources, lack of skilled human resources, poor governance structure, ineffective stakeholder engagement – 'working silos' and inefficient data management. Among these challenges, the lack of financial resources was ranked the highest as highlighted in Chapter 5, Section 5.4 and most participants suggested that the budget allocated for water resource monitoring was inadequate for monitoring equipment and replacing aging monitoring infrastructure. Moreover, funds are directed to avenues like provision of sanitation and housing that are tangible to the voters of the country. In addition, Ruiters (2015) identified that the water and sanitation sector is seriously under-financed, revenue management is poor and there is limited or no investment in maintenance and these have led to the deterioration and the eventual collapse of infrastructure at municipal level/sphere and ultimately financial resource would be needed to replace infrastructure. Lack of skilled human resources further compound the issue due to a lack of retention strategies for key staff members involved in water resource monitoring. In addition, mentorship of young and new staff for transfer of knowledge is not encouraged. It was also discovered that water resource governance structures are weak and fragmented as a result of lack of accountability, politics and unclear roles and responsibilities and lack of stakeholder engagement in water resource monitoring system. Engaging stakeholders would allow for data sharing and integration of water resource monitoring programmes; however, inefficient data management is a stumbling block due to a lack of competent and/or accredited laboratories and the use of outdated technologies for data collection, analysis and dissemination. It was also found that the success of a water resource monitoring framework does not reside only in scientific and technological developments but also in the role of government at all levels in effectively developing and implementing policies and in communicating these policies to the public. Moreover, strong partnerships must be fostered amongst all stakeholders who embrace the principles of sustainable development to conserve this invaluable resource (Sershen, 2016).

The challenges and opportunities presented in this study form part of the aims outlined by the South African government with regards to National Water Resource Strategy (NWRSIandII). By using local knowledge gathered from interviews, focus groups and questionnaires, this research implies that integration of water resource monitoring programmes is the most suitable solution to the challenges listed above. In that manner the synergies between monitoring programmes are taken advantage of and stronger partnerships would be fostered. Some of the advantages would include; reduction in monitoring costs and reduction in the need for skilled human resources. Integration compels all stakeholders to comply with certain data quality standards through the use of accredited laboratories. The current water resource monitoring structures i.e. National Water Monitoring Committee and Integrated regional Water Monitoring Committee are failing to realize the advantages of integration due to a lack of commitment from key stakeholders, rapidly changing water management institutions (restructuring of department) and all the above-mentioned challenges such as lack of financial resources. Ruiters (2015) suggests that government would benefit from establishing structures that are recognized, mandated and promote structured partnerships with key stakeholders (MOU), good data management, having available appropriate skills (including technical and operational skills, that are able to secure funding in the form of loans and that are able to deal with the challenge of capacity constraints in terms of both human skills capacity and financial capacity (Ruiter, 2015). Thus, this research demonstrates that through a combination of both quantitative and qualitative methods, a comprehensive challenge inventory and identification of entry points towards formulating an effective water resource monitoring management system can be achieved.

6.3 RECOMMENDATIONS

I. Based on the findings above the researcher recommends that there is an urgent need for the DWS to develop an effective

framework that will facilitate sustainable water resource monitoring for all stakeholders involved without marginalizing the weaker or smaller institutions. The key to solving the above challenges lies in participation at all levels, national, regional and local. One of the ways effective water resource management can be achieved is through institutional reform; as one of the biggest concerns is that water activities, including monitoring are often split among a number of ministries and departments at the national level. This fragmentation of responsibilities among sector based ministries and administrative agencies hinders co-ordination and hampers attempts to integrate water management activities. Alignment of policies and strategies is needed to address this issue and create an environment where water resources can be managed sustainably.

II. Another way to help build sustainable water resource management institutions is through capacity building and strengthening. This includes skills and institutional memory transfer from the experienced players in water resource management, to the young and new employees as the quality of the data produced by water resource monitoring programmes depends on the quality of the work done by field and laboratory staff. It is therefore imperative that staff is adequately trained for the work they are expected to do according to the National Water Act of 1998 and Water Services Act of 1997. For monitoring programmes to be sustainable, comprehensive strategies and training programmes need to be designed for personnel development. There is a need for capacity building within institutions to develop financially viable systems, to design policy structures which can respond to economic situations and avoid duplication of responsibilities. Other recommendations

include; informed decision making, citizen empowerment, academia focussing on applied research, educating local government councillors and integration of strategic mandates.

III. Creation and/or optimization of water resource monitoring databases is also a very viable way for sustainable water resource management which includes capacity assessment for each institution, as it allows for timely reporting and effective communication among stakeholders. Databases should be used to establish closer working relations among the stakeholders in public and private institutions that monitor and use water quality information in SADC region and to identify the capacity gap on a regional scale. Such databases may be used to initiate an institutional restructuring project to address the gaps identified as it has been noted in other countries that effective water resource management can be achieved by putting in place and managing monitoring networks.

IV. Enabling legislation is the basis upon which any development efforts can be pursued to achieve sustainable water resource monitoring. An example would be to encourage stakeholder driven development and foster leadership in the face of a changing government. Development that is stakeholder driven creates an environment of accountability, thereby making them more active participants of the process. In the same token, good leadership also encourages responsibility and ownership and ultimately the drive to seek solutions for the region and the country as a whole.

6.4 FUTURE RESEARCH FOCUS

Water resource monitoring in South Africa is a topic that has not received enough attention from researchers. Technical studies have been done in

the country that look at reviewing, evaluating and optimizing of the water resource monitoring network, while certain government reports have not been published but have looked into water resource monitoring as a tool for managing water resources and what has slowed the implementation of integrated water resource management in South Africa. More research can be done to unearth more of the dynamics at play in water resource monitoring and the behaviour of stakeholders alike. Firstly, research can be conducted to assess the challenges in water resource monitoring and provide sustainable solutions; secondly, research can be done with the aim of quantifying the impact of policy reforms in the water sector. Lastly, research can be done on how effective regulation and co-operative governance for water sector can be achieved in South Africa through participatory processes that aim at developing priority water research questions.

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APPENDICES

Appendix A: DWS National and Regional Official Questionnaire

UNIVERSITY OF THE WITWATERSRAND

FACULTY OF SCIENCE

SCHOOL OF GEOGRAPHY, ARCHAEOLOGY AND ENVIRONMENTAL STUDIES

TITLE OF RESEARCH: “Towards a Sustainable Water Resource Monitoring Framework”

This interview guide aims at collecting empirical data in partial fulfilment of the requirements for a PhD Degree in Geography and Environmental Studies. It seeks to investigate the factors and processes that currently contribute to fragmentations in the institutional setup that are mandated to manage water resources in South Africa. The study will specifically be interested in understanding the factors that make it difficult to develop a framework through which effective water resource management can be pursued in order to promote sustainable water resource monitoring and development. Your responses are strictly confidential to the maximum extent allowed by the law. Your cooperation is highly appreciated.

QUESTION GUIDE DESTINED FOR DEPARTMENT OF WATER AND SANITATION NATIONAL AND REGIONAL EMPLOYEES IN ORDER TO UNDERSTAND THEIR VIEWS ON THE CURRENT WATER RESOURCE MONITORING MANAGEMENT SYSTEM AND WHAT THEIR CURRENT CHALLENGES ARE IN TERMS OF THE CURRENT WATER RESOURCE MONITORING MANAGEMENT SYSTEM IN SOUTH AFRICA

1. Are you in a position to tell me about yourself, your function and how you carry out your responsibilities at the Department of Water and Sanitation (DWS)? Please elaborate.

2. How long have you worked at DWS?
3. How long have you worked in the South African water sector?
4. Are you in a position to identify stakeholders you interact with as part of your responsibilities? Please elaborate.
5. Would you be in a position to share with me some of the training you have undertaken since joining DWS?
6. Would you be in a position to share with me the monitoring programmes you are involved?
7. Would you be in a position to identify what organizations exist which are responsible for water resource monitoring in South Africa?
8. To what extent would you consider these institutions to be fulfilling their roles?
9. Are you in a position to share with me some of the challenges organizations/institutions are facing when implementing their policies?
10. Are you in a position to share with me any legislation that supports water resource monitoring in South Africa?
11. Would you consider climate change to have an effect on water resources in South Africa? If yes, how?
12. Would you consider urbanization to have an effect on water resources in South Africa? If yes, how?
13. Would you be in a position to share your opinions on the sustainability of water resource monitoring programmes?
14. What would be your perspectives on the impact of water monitoring on Integrated Water Resource Management reforms?
15. Would you be in a position to share your opinions on the challenges that exist with regards to water resource monitoring?

16. Are you in a position to share with me the communication channels you use to transmit water resource monitoring data to water users?
17. What would you consider to be the relationship between Regional offices and the DWS National Office?
18. Would you be in a position to share your opinions on the role of human resource strategies in DWS in promoting competence in water resource monitoring environment?
19. Would you consider quality assurance and quality control of water resource monitoring data to be of acceptable standard?
20. What would be your perspectives on the annual budget set aside for water resource monitoring?
21. Would you be in a position to share your opinion on whether it is sufficient for the water resource monitoring needs?
22. What would you consider to be the key responsibilities of the DWS in terms of stakeholder engagement?
23. What would be your opinion on DWS as an effective water sector leader?
24. What would be your opinion on DWS as an effective water sector regulator?
25. Would you be in a position to propose some recommendations on how the gaps can be closed, if there are any within the water sector with regards to water monitoring and information systems?
26. Would you be in a position to share your opinions on the current regulatory environment in your institution?
27. Would you be in a position to share your opinions on the current regulatory environment in the water sector?
28. Based on what we have discussed, is there anything you would like to add?

Appendix B: DWS External Stakeholder Questionnaire

UNIVERSITY OF THE WITWATERSRAND

FACULTY OF SCIENCE

SCHOOL OF GEOGRAPHY, ARCHAEOLOGY AND ENVIRONMENTAL STUDIES

TITLE OF RESEARCH: “Towards a Sustainable Water Resource Monitoring Framework”

This interview guide aims at collecting empirical data in partial fulfilment of the requirements for a PhD Degree in Geography and Environmental Studies. It seeks to investigate the factors and processes that currently contribute to fragmentations in the institutional setup that are mandated to manage water resources in South Africa. The study will specifically be interested in understanding the factors that make it difficult to develop a framework through which effective water resource management can be pursued in order to promote sustainable water resource monitoring and development, taking Gauteng as a case study. Your responses are strictly confidential to the maximum extent allowed by the law. Your cooperation is highly appreciated.

QUESTION GUIDE DESTINED FOR THE DEPARTMENT OF WATER AND SANITATION (DWS) EXTERNAL STAKEHOLDERS IN ORDER TO UNDERSTAND HOW THEY VIEW THE CURRENT WATER RESOURCE MONITORING MANAGEMENT SYSTEM AND WHAT THEIR CHALLENGES ARE IN TERMS OF THE CURRENT WATER RESOURCE MONITORING MANAGEMENT SYSTEMS IN SOUTH AFRICA.

1. Are you in a position to tell me about yourself, your function and how you carry out your function at your institution? Please elaborate.
2. How long have you worked at your institution?

3. How long have you worked in the South African water sector?
4. Are you in a position to identify the stakeholders you interact with as part of your responsibilities? Please elaborate.
5. Would you be in a position to share with me some of the training you have undertaken since joining your institution? Please elaborate.
6. Would you be in a position to share with me the monitoring programmes you are involved in? Please elaborate.
7. Would you be in a position to identify what systems/institutions exist which are responsible for water resource monitoring in South Africa? Please elaborate.
8. To what extent would you consider these institutions to be fulfilling their role?
9. Would you be in a position to share with me some challenges institutions are facing when implementing their policies with regards to water monitoring? Please elaborate.
10. Would you be in a position to share with me any legislation that supports water resource monitoring in South Africa? Please elaborate.
11. Would you consider climate change to have an effect on water resources in South Africa? If yes, how?
12. Would you consider urbanization to have an effect on water resources in South Africa? If yes, how?
13. Would you be in a position to share your opinions on the sustainability of water resource monitoring programmes in South Africa? Please elaborate.
14. What would be your perspectives on the impact of water monitoring on Integrated Water Resource Management reforms?

15. Would you be in a position to share your opinions on the challenges that exist with regards to water resource monitoring in South Africa?
16. Are you in a position to share with me the communication channels you use to transmit water resource monitoring data to water users?
17. Would you be in a position to share your opinions on the role of human resource strategies in your institution in promoting competence in water resource monitoring environment?
18. Would you consider quality assurance and quality control of water resource monitoring data to be of acceptable standard?
19. What would be your perspectives on the annual budget set aside for water resource monitoring in your institution?
20. Would you be in a position to share your opinion on whether it is sufficient for the water resource monitoring needs in your institution?
21. What would be your perspectives on the role of Gauteng region in water monitoring information systems in the DWS?
22. What would you consider to be the key responsibilities of DWS in terms of reporting on water resources?
23. What would consider to be the responsibilities of DWS in terms of stakeholder engagement?
24. What would be your opinion on DWS as an effective water sector leader?
25. What would be your opinion on DWS as an effective water sector regulator?
26. What would you consider to be issues or challenges in water resource monitoring information systems?
27. Would you be in a position to share your opinions on the current regulatory environment in your institution?

28. Would you be in a position to share your opinions on the current regulatory environment in the water sector?
29. Would you be in a position to share your opinions on whether water resources regulation (primarily the regulation of abstractions and discharges) is being enforced at a regional level in terms of compliance and enforcement?
30. Based on what we have discussed, is there anything you would like to add?

Appendix C: Focus Group Discussion Guide

UNIVERSITY OF THE WITWATERSRAND

FACULTY OF SCIENCE

SCHOOL OF GEOGRAPHY, ARCHAEOLOGY AND ENVIRONMENTAL STUDIES

TITLE OF RESEARCH: “Towards a Sustainable Water Resource Monitoring Framework”

This interview guide aims at collecting empirical data in partial fulfilment of the requirements for a PhD Degree in Geography and Environmental Studies. It seeks to investigate the factors and processes that currently contribute to fragmentations in the institutional setup that are mandated to manage water resources in South Africa. The study will specifically be interested in understanding the factors that make it difficult to develop a framework through which effective water resource management can be pursued in order to promote sustainable water resource monitoring and development, taking Gauteng as a case study. Your responses are strictly confidential to the maximum extent allowed by the law. Your cooperation is highly appreciated.

QUESTION GUIDE DESTINED FOR FOCUS GROUPS

1. Would you consider climate change to have an effect on water resources in South Africa? If yes, how?
2. Would you consider urbanization to have an effect on water resources in South Africa? If yes, how?
3. Would you be in a position to share your opinions on the sustainability of water resource monitoring programmes in South Africa?

4. What would be your perspectives on the impact of water monitoring and reporting systems on Integrated Water Resource Management reforms?
5. Would you be in a position to share your opinions on the challenges that exist with regards to water resource monitoring in South Africa?
6. Are you in a position to share with me the communication channels you use to transmit water resource data to water users?
7. Would you be in a position to share your opinions on the role of human resource strategies in DWS in promoting competence in water resource monitoring environment?
8. Would you consider quality assurance and quality control of water resource monitoring data to be of acceptable standard in the South Africa?
9. What would be your perspectives on the role of DWS in water monitoring and information systems in the DWS?
10. What would you consider to be the responsibilities of the DWS in terms of reporting on water resources?
11. What would you consider to be the responsibilities of the DWS in terms of stakeholder engagement?
12. What would be your opinion on DWS as an effective water sector leader?
13. What would be your opinion on DWS as an effective water sector regulator?
14. What would you consider to be the issues or challenges on water monitoring and information systems?
15. Would you be in a position to share your opinions on the current regulatory environment in your institution?
16. Would you be in a position to share your opinions on the current regulatory environment in the water sector?

17. Would you be in a position to identify what systems/institutions exist which are responsible for water resource monitoring in South Africa?
18. To what extent would you consider these institutions to be fulfilling their mandate?
19. What would you consider to be the challenges institutions are facing when implementing their policies?
20. Are you in a position to share any legislation that supports water resource monitoring in South Africa?
21. Based on what we have discussed, is there anything you would like to add?

Appendix D: Participant Information Sheet

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: GEOGRAPHY: TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

PARTICIPANTS INFORMATION SHEET

THIS IS MEANT FOR DWS NATIONAL AND REGIONAL EMPLOYEES

INVESTIGATOR: SIMPHIWE CHABALALA (PhD Candidate)

STUDENT NUMBER: 1028837

TITLE OF RESEARCH: Towards a Sustainable Water Resource Monitoring Framework

INSTITUTION: University of the Witwatersrand; School of Geography, Archaeology and Environmental Studies.

TELEPHONE NO: +27 83 417 4727

1. INTRODUCTION

Good day Sir/Madam,

My name is SIMPHIWE CHABALALA, a PhD candidate in the School of Geography, Archaeology and Environmental Studies at the University of the Witwatersrand, Johannesburg, South Africa. I am conducting a study titled: Towards a Sustainable Water Resource Monitoring Framework.

I would like to invite you to participate in completing the questionnaire on the management aspects of water resource monitoring. This exercise will

require 40 minutes of your time. Before agreeing to participate, it is important that you read and understand the purpose of the study.

This information sheet is to help you decide if you would like to participate. Do not hesitate to ask any question you might want to. You may refuse to participate and you are also free to skip any question and withdraw from the study at any stage and this will not be held against you. If you decide to take part in this study, you will be invited to sign a consent form confirming that you understand and accept to be part of the study. You will also be given a copy to keep.

2. PURPOSE OF THE STUDY AND SELECTION OF INTERVIEWEES

My research focuses on investigating the factors and processes that currently contribute to fragmentations in the institutional setup that are mandated to manage water resources in South Africa. The study will specifically be interested in understanding the factors that make it difficult to develop a framework through which effective water resource management can be pursued in order to promote sustainable water resource monitoring and development. The information provided will be used solely for academic purposes.

3. PROCEDURES

The questionnaire will be administered in the consenting participant's private office at their place of work, any other private office or at a location of their choice where the conversation cannot be heard. The whole interview will be recorded and kept in a password computer accessed only by the researcher and destroyed two years after completion of the study. The consent form is specifically designed for this purpose; that if you do not agree, you do not have to sign. All data will be destroyed two years after the publication of the thesis. A copy of the thesis will be available to participants if requested. And the interview will be conducted in English.

4. POTENTIAL RISKS AND BENEFITS TO PARTICIPANT

There are no risks involved in participating in this study. It will only contribute to improving the management of water resources monitoring.This will include; identifying challenges in the water resource monitoring, identifying entry points towards formulating an effective water resource monitoring management system, identifying and reviewing factors accounting for non-existence of water resource monitoring management system in South Africa. And lastly, collate recommendations towards building effective management for water resource monitoring.

5. CONFIDENTIALITY AND ANONYMITY

Participation in this questionnaire is voluntary and no fee will be paid. Participants in this questionnaire should also not be less than 18 years of age. Contributions will be strictly anonymous. At no point during the questionnaire will you be asked to record your name or any personal information that can be used to identify you later on. You are also free to stop the questionnaire or skip any question that you find offensive or are uncomfortable answering. You may also withdraw at any time without any consequences or any explanation.

The data collected from this research will be used for academic purposes only. The data will be used to compile a PhD thesis through publication in scientific journals and submitted to the Faculty of Science, University of the Witwatersrand. Any information that may identify you or any references made in this study will not be disclosed. The results would be accessed through the University website and Wits library archives open to the public.

6. RESEARCHER CONTACT DETAILS

For further information regarding the research or the implications of your participation, please do not hesitate to contact me or my supervisor on:

STUDY INVESTIGATOR

Simphiwe Chabalala

Phone No: +27 83 417 4727.

E-mail: 1028837@students.wits.ac.za

SUPERVISOR DETAILS

Dr Danny Simatele

Phone No: +27 11 717 6515

Email: Danny.simatele@wits.ac.za

Appendix E: Consent Form

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

CONSENT FORM

THIS IS MEANT FOR DWS NATIONAL AND REGIONAL EMPLOYEES

I hereby confirm that I have been well informed by study investigator Ms. Simphiwe Chabalala about the nature, conduct, benefits and risks of the study. I have also received, read and understood the participant information sheet regarding the study. I am aware that the results of the study will be anonymously processed and may, at any stage without prejudice withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and therefore; I declare that; I am above 18 years old and prepared to voluntarily participate in the study.

I do agree to be audio-recorded /participate in the questionnaire. ☐
(Tick if appropriate)

I do not agree to be audio-recorded /participate in the questionnaire. ☐

PARTICIPANT CONSENT

Signature

_____Date_____

I, Simphiwe Chabalala, herewith confirm that the above participant has been fully informed about the nature and conduct of the above study.

STUDY INVESTIGATOR

Simphiwe Chabalala

Signature

_____Date_____

Appendix F: Application to Human Research Ethics Committee Clearance – (Non-Medical)

University of the Witwatersrand, Johannesburg

Ethics Application Form for Human Research Ethics Committee (HREC Non-Medical) (Revised December 2012)

Use this form in applying for clearance of research involving human participants.

Instructions

Completed applications must be submitted to the Research Office approximately three weeks before each of the monthly meetings. The deadlines are available on the Wits Research website http://www.wits.ac.za/academic/research/ethics.htm/7075/ethics.html

Applications must be submitted as hard copies, one of which must be an original (see checklist below for numbers of copies required). Electronic submissions will not be accepted.

All submissions and materials must be typed. Handwritten submissions are **NOT** acceptable.

Incomplete applications will **NOT** be considered.

Applications will **NOT** be processed if signatures from applicant or supervisor are missing.

Photocopying should be done 'back-to-back' to save paper.

Glossy and fancy binding is **NOT** necessary.

Necessary supporting documents (e.g. *Participant Information Sheet, Consent Form*, copies of instruments), must be stapled to the *Ethics Application Form.*

Complete this checklist to show what documents you have submitted.

☑ Check list For all research:		No. of copies required
✓	Completed Ethics Application Form	15
✓	Copies of the research proposal	4
✓	Copies of proposed research instruments (e.g. questionnaires/interview schedules)	4
✓	*Participant Information Sheet* (for each different sample group)	4
✓	*Consent Form* [*Assent Form* for under 18s] (for participant's signature) (for each different sample group)	4
Where applicable (Attach to this form):		
✓	Relevant permissions (from, e.g. company's HR department, National authorities such as Education, Correctional Services, etc.) or other legally required consent	4
	Any other appropriate consent forms (e.g. consent forms for members of focus groups, consent forms (for video or photography), etc.	4
	Guardian *Consent Form* (for participants under the age of 18)	4
	Other (please specify)	4

Declaration

I recognise that it is my responsibility to conduct my research in an ethical manner according to Guidelines of the University of the Witwatersrand, according to any laws and/or legal frameworks that may apply, and according to the norms and expectations of my discipline.

In preparing this Application for Ethics Clearance form, I have consulted the ***Guidelines for Human Research Ethics Clearance Application /non-medical*** (available on this web site http://web.wits.ac.za/Academic/Research/Applications.htm) and have familiarised myself with the ethical guidelines specific to my discipline.

Signature

Name of researcher/applicant: Simphiwe Chabalala

Researcher's personal data

Surname: Chabalala						Name: Simphiwe						
Title:		Prof		Dr		Mr	✓	Ms		Mrs		Other:
School:	Archaeology, Geography and Environmental Studies											
Staff / Student number:	1028837						✓	Full time		Part time		Staff
Your telephone(s):	083 417 4727											
Your Email:	1028837@students.wits.ac.za											
Name of Supervisor (if applicable):	Dr Danny Simatele											
Supervisor's address:	email Danny.simatele@wits.ac.za											

Supervisor's number(s):	tel. 011 717 6515

Specifics about the research project
Title of research project
Towards a sustainable and integrated water resource monitoring framework in South Africa.

Is this research for degree purposes?	✓	Yes		No			
If so, for what degree?		Honours		Masters (dissertation)		Masters (research report)	
	✓	PhD		Other (specify):			
Has it been approved by the relevant higher degrees committee or other relevant unit?	✓	Yes		No		Submitted and pending	

List the names and affiliations of any *additional* researchers who will be covered by this ethics protocol
N/A

Where will the research be carried out?

The questionnaires will be administered in the consenting participant's private office at their place of work, or any other private office or at a location of their choice where the conversation will be private and cannot be heard i.e. privacy will be guaranteed.

What are the aims and objectives of the research? (Please list; be brief)
The current water resource monitoring management system has no clearly defined roles and responsibilities which results in the fragmentation of institutional structure; therefore the aim is to investigate factors that are accounting for the non-existence of an effective and unified water resource monitoring system in South Africa. The objectives of the study are as follows; Create an inventory of current challenges in water resource monitoring system in South Africa, Identify entry points towards formulating an effective water resource monitoring management system, Identify and review factors accounting for non-existence of water resource monitoring management system in South Africa.

Do you have any financial or material interest associated with your research participants or with the organisations that you will work with during your research?					
	Yes		No	✓	Potential conflicts of interest may exist
Please explain how you will manage any existing or potential conflicts of					

interest, if applicable.

While there is a potential conflict of interest, the following will help manage it;

i) The PhD study is independent of my employment at Department of Water and Sanitation, although there has been an expression of interest or an intention from the Department of Water and Sanitation on how the study will enhance the organization.

ii) The Department of Water and Sanitation also has no influence on the outcomes of the study as the thesis will be written from an academic perspective. Preliminary findings will not be shared with the Department of Water and Sanitation and no submissions will be made to them until the study is completed.

iii) The PhD study is not funded by the Department of Water and Sanitation.

INFORMATION RELATING TO ETHICAL MATTERS
Protocols submitted to the Committee must have sufficient information to enable the committee to judge the ethical implications of the proposed research. Please be brief and concise but also as specific and informative as possible

Formal permission					
Has appropriate formal permission been obtained, if required (e.g. employer, government department, land owner, etc.)?					
	Yes (attached)		Not required	✓	Pending (must be supplied before permission is granted)
Obtaining permission is necessary when conducting research *within the premises* of a particular site such as an ethnography of the functioning of a supermarket or a school, or the way staff interact with clients in a clinic, or of how the HIV Unit in the City of Johannesburg functions. Please read the detailed guidelines on the Ethics website http://web.wits.ac.za/Academic/Research/Applications.htm					

How will data on human research participants be collected (instruments, methods, procedures)? (Attach instruments as an appendix)	
✓	In written format (e.g. questionnaires, diagnostic tests, etc.)
	Completion of on-line instruments (e.g. questionnaires)
✓	Individual interviews (e.g. structured, semi-structured, etc.)
✓	Group interviews (e.g. seminar/discussion groups, focus groups,

	etc.)
	Ethnographic observation, participant observation, other informal descriptive, and/ or interactive methods
	Community-based methods or techniques such as drama workshops, community theatre, training workshops, participant rural appraisal (PRA), rapid rural appraisal (RRA), etc.
	Research on/in therapeutic or counselling contexts
	Observation of public performance, and/or public behaviour observation
✓	Photography, video and/or audio recording (specific separate consent forms may be required)
	Other research methods or techniques (specify in this line).

Brief details of instruments to be used (attach instrument or draft to this application)

Questionnaire Guides and Focus Group Discussions for participants (see attached Appendix A, B, C). Their consent will be solicited to audio record the discussions for subsequent transcription.

Appendix A – Relevant permission from the National Department of Water and Sanitation

Appendix B – Participant Information Sheet, Consent Form and Questionnaire Guides for DWS National and Regional Employees

Appendix C- Participant Information Sheet, Consent Form and Questionnaire Guides for DWS External Stakeholders

Appendix D- Participant Information Sheet, Consent Form and

Questionnaire Guides for Focus Group Discussions

Who will the research participants be?

Brief description of human participants, including age range and sample size, for each sample:

DWS National and Regional Employees involved in water monitoring and information systems.

DWS External Stakeholders e.g. Employees of Randwater, Midvaal, ESKOM, NGO's etc. involved in water monitoring and information systems.

The sample size is 50 as I am targeting management and experts in the field and more will be identified depending on referrals (snow-ball sampling). All participants must be older than 18 years.

Does this research expose either the participant or the researcher to any potential risks or harm that they would not otherwise be exposed to?		Yes	✓	No

If 'yes', explain:

Participants in this questionnaire would not be less than 18 years of age and their concern will be solicited before the interviews begin. The nature of the questionnaire will be explained to them in full detail and they will be informed of their rights. They will be made to understand that their contributions will be strictly anonymous .At no point during the questionnaire will the participants be asked to record their names or any personal information that can be used to identify them later on. They will

also be free to stop the questionnaire or skip any question that they find offensive/uncomfortable answering. They may also withdraw at any time without any consequences.

Will research involve vulnerable categories?		Yes	✓	No

If so, state which ones: N/A
How will any existing vulnerabilities among research participants be addressed? N/A

NB: The term 'vulnerable categories' includes, among others, children under 18, orphans, prisoners, persons with cognitive or communication disorders, people who are traumatised or currently in traumatic situations.

Where necessary, include details of steps to be taken to facilitate data collection across language barriers (e.g. interpretation or translation).

How will informed consent be obtained?
How will potential participants be identified / selected / recruited? The technique that will be used here is expert sampling where potential respondents are chosen in a non-random manner based on their expertise on the issue being studied. It was chosen mainly because experts tend to be more familiar with the subject matter; water resource monitoring and information systems and their opinions are credible. The unit of analysis is the National and Regional office representatives working within the water resources monitoring and information systems section and the management thereof; to investigate their behavior and attitude to the current fragmented institutional framework.

The sample size will be 50 participants involved in focus research groups and individual interviews. It is highly likely that other stakeholders involved in water resource monitoring and information systems are not mentioned in the above table, those will be discovered by the snowball technique. Snowball sampling is a non-probability sampling technique that will be used in this study to identify potential subjects where they are hard to locate. This technique was chosen because the sample for the study is very limited to a small sub-group of the population.

What will participants be told about the research (including the promises to be made)?

It will be in the form of the following;

Introduction: Introduce myself and extend an invitation to participate, stipulating how long it will take to complete the questionnaire. And an information sheet will be introduced to help participants decide if they would like to participate in the study. They would be free to withdraw from the study at any stage and it would not be held against them. And also they will be offered a copy of the consent form to keep.

Purpose of the study: The research focus will be explained and that the participant will be making a contribution to improving the management of water resources monitoring. They will be reassured that the information provided will be used solely for academic purposes.

Procedures: Questionnaires will be administered in the consenting participant's private office at their place of work, or any other private office where the conversation cannot be heard or at a location of their choice. The whole interview will be recorded and kept in a password computer accessed only by the researcher and destroyed two years after the completion of the study. The research data gathered will be destroyed 2 years after the publication of the thesis. A copy of the thesis

will be available to participants if requested. And the interview will be conducted in English.

Potential risks and benefits to participant: It will be explained that there no risks involved in participating in this study. It will only contribute to improving the management of water resources monitoring.

Confidentiality and anonymity: Participants will not be paid for participating in the study and participation in this study is voluntary. At no point during the questionnaire will the participant be asked to record their names or any personal information that can be used to identify them later on. They are also free to stop the questionnaire or skip any question that they find offensive or are uncomfortable answering. The participant may withdraw at any time without any consequences or any explanation. Any information that may identify the participant or any references made in this study will not be disclosed. The results may be accessed through the Wits library archives.

Researcher and Supervisor details: Contact details will be provided.

How will informed consent be obtained?

✓	Formal (Signed form)		Informal (e.g. verbal)		Other

Briefly explain your strategy for ensuring informed consent

To ensure informed consent from the respondents, they will have to read the participant information sheet or be read to and explain to their understanding of the nature, conduct, benefits and risks of the study. They will be made to understand that the result of the study will be anonymously processed and that they may, at any stage without prejudice withdraw their consent and participation. They will be told to

freely ask questions that need clarification and will not forced to participate. If they are willing to participate, they will be asked to sign the consent form. They will receive the following; Participant Information Sheet – To help them decide if they want to participate or not. Consent Form – To sign if they agree to participate.
Attach *Participant Information Sheets* and *Consent Forms* for each sample group, and/or other related materials

NB*:* ***Consent*** in social science and humanities research involving human participants: Where informal ethnographic or participant observation methods are used or where signed *Consent Forms* are not possible, or for research involving group contexts (focus group, Participant Rapid Assessment, Rapid Rural Appraisal, public performance, workshops) **state how the quality of informed consent will be assured**. It is essential that participants in research be fully informed and agree, on this basis, to participate in the research.

Protecting participant identities				
Can confidentiality be guaranteed?	✓	Yes		No
Can **anonymity** be guaranteed in resulting reports, theses and/or publications?	✓	Yes		No
Explain how this will be done? (What will participants be told in this regard?) The participants will be briefed that participation in this questionnaire is voluntary and no fee will be paid and that they should also not be less than 18 years of age and their contributions will be strictly anonymous				

and confidential. Part of the information for the study (focus groups) will be derived from working with a committee recognized by the Department of Water and Sanitation in the Gauteng Region. The names of the members and the name of the committee will not be disclosed and their comments and discussions will be confidential.

At no point during the questionnaire will the participant be asked to record their name or any personal information that can be used to identify them later on. They are also free to stop the interview or skip any question that they find offensive or are uncomfortable answering. They may also withdraw at any time without any consequences or any explanation.

NB: While confidentiality may be desirable, it cannot be guaranteed in, for example, focus groups, or ethnographic observation. Similarly anonymity should be preserved in questionnaires, but cannot be offered in workshop methodologies, focus group research, etc. Participants should have the right to remain anonymous in the final report, and this must be respected in handling of all data relating to them. Participants need to be informed about these issues.

Protection of data during and after the research
How will the data be protected while the research is in progress? (This includes how the identities of participants will be protected). Any information that may identify the participant or any references made in this study will not be disclosed. All the data from semi-structured questionnaires, audio and text transcript of the interview may, with specific consent from the respondents be filed and kept in a password protected computer by the researcher until the research is completed and discarded two years after completion of the interviews and studies.
What is to be **done with the research data** after completion of the project?

	Stored in archives (specify)		Stored in on-line data base (specify)
✓	Stored in password protected computer	✓	Stored in digital form with all identifying feature removed
✓	Destroyed after 2 years (insert numbers of years)		

Explain how the data will be securely stored during this time

All interviews will be recorded and kept in a password computer accessed only by the researcher and destroyed two years after the completion of the study.

NB: 'Raw' or unprocessed data, especially where the identity or personal data of research participants is included, must be safeguarded and preserved from unauthorised access. Data may be destroyed after use, but preservation in an archive or personal collection may also be appropriate, desirable or even essential. For instance, data sets that contain historically important information or information that relates to national heritage must be preserved and should be placed in a public archive where possible and appropriate.

All data should be preserved in a way that **respects the nature of the original participants' consent**. If you are unsure about the procedure of data management and storage, please contact Nina Lewin (ninalewin@gmail.com)

Access to the research results / reports
How will the results be reported? The data collected from this research will be used for academic purposes only. It will be compiled into a PhD thesis through publication in scientific journals and submitted to the Faculty of Science, University of the Witwatersrand. Any information that may identify the participant or any references made in this study will not be disclosed.
Who will have access? The results of the study would be accessed through the Wits library archives. Everybody will have access to the results; policy makers, academicians, interested parties provided they are for personal or teaching exercises otherwise permission is needed from the university.
Note: All Wits Masters and PhDs are stored in the main library as well being made available on the internet.

SIGNATURES (REQUIRED)

In signing this form, the researcher and supervisor (if any) of this project undertake to ensure that any amendments to this project that are required by the Human Research Ethics Committee are made before the project commences.

Declaration: We, the signatories, declare that all information on this form is correct and that we will strive to maintain the highest ethical standards in

this research at all times, according to disciplinary and university expectations, recognising that ethical practice in research is always a continuing process.

	Date	Name	Signature
Applicant		Simphiwe Chabalala	
Supervisor		Dr Danny Simatele	

Appendix G: Human Research Ethics Committee Clearance Certificate – (Non-Medical))

Research Office

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

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H15/03/01**
PROJECT TITLE	Department of Water and Sanitation - National and Regional Office Employees
INVESTIGATOR(S)	Ms S Chabalala
SCHOOL/DEPARTMENT	GAES/Geography
DATE CONSIDERED	20 March 2015
DECISION OF THE COMMITTEE	Approved unconditionally
EXPIRY DATE	27 April 2017
DATE 28 April 2015	**CHAIRPERSON** pp (Professor T Milani)

cc: Supervisor : Dr D Simate

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

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** 29/04/2015

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix H: Plagiarism Report

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ORIGINALITY REPORT

%5	%2	%3	%0
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.dti.unimi.it Internet Source	%1
2	Jin-Yong Lee and Kwon, Kideok D.. "Current Status of Groundwater Monitoring Networks in Korea", Water (20734441), 2016. Publication	%1
3	oldweb.roundrockisd.org Internet Source	%1
4	Hajer, Maarten; Nilsson, Måns; Raworth, Kate; Bakker, Peter; Berkhout, Frans; de Boer, Yvo; Rockström, Johan; Ludwig, Kathrin and Kok, Marcel. "Beyond Cockpit-ism: Four Insights to Enhance the Transformative Potential of the Sustainable Development Goals", Sustainability (2071-1050), 2015. Publication	<%1
5	Jootun, Dev McGhee, Gerry Marland, Glenn. "Reflexivity: promoting rigour in qualitative	<%1