Development of A Success Model for Water Management Information Systems

By

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DECLARATION

I, Gordon Nana Kwesi Amoako, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgments indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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ABSTRACT

The management of water resources traverses many disciplines and involves multiple stakeholders. Water Management Information Systems (WMIS) is a combination of technological resources – software and hardware – and tools implemented to enhance the roles and functions, and the decision-making processes of water resource management. WMIS have been acknowledged to be a critical actor and part of the water resources management processes. Though the water resources management literature presents substantial evidence to back this claim, there is insufficient evidence of research in the IS literature to understand factors that affect the success of WMIS implementations. More importantly, due to the complexity of managing the resource, factors surrounding the systems and organisational context of water management institutions affect its implementations. The aim of this study is thus to develop, test and validate a model for understanding WMIS success in the water resources management context. This integrated model combines the system and organisational factors to develop the success model.

The WMIS success model was conceptualized and operationalised based on the principles of water resources management, specifically the Integrated Water Resources Management (IWRM), and two IS models – HOT-Fit Framework and DeLone and McLean IS success model. The model consisted of the system and organisational factors, and a set of outcome constructs or net benefits – WMIS for Water Management Operations and WMIS for Water Management Decision-Making – that represented WMIS success. The system factors consisted of five dimensions namely; WMIS System Quality, WMIS Information Quality, Service Quality, System Use and User Satisfaction; whereas the organisation factors consisted of Leadership, Structure and Environment constructs.

The model was tested and validated using cross-sectional data collected from users of WMIS from various designations of the Department of Water and Sanitation in the City of Cape Town metropolitan municipality in Cape Town, South Africa. The study recorded a 38% response rate. To analyse and validate the model, a Partial Least Squares (PLS) approach to Structural Equation Modelling (SEM) was employed.

Overall, the variance explained in WMIS for Water Management Operations was 53% whiles WMIS for Water Management Decision-Making was 12%. The model fit was deemed substantial. The direct, indirect and total effects showed that, for the system factors, User Satisfaction (β =0,69) had the strongest total effect on WMIS for Water Management Operations, whereas System Use (β =0,25) had strongest total effect on WMIS for Water Management Decision-Making; in the organisation dimension, Environment (β =0,12) had the strongest total effect on WMIS for Water Management Operations, whereas Leadership (β =0,19) had the strongest total effect on WMIS for Water Management Decision-Making. User Satisfaction (β =0,69) had the strongest direct and total effect on WMIS for Water Management Operations, whereas System Use (β=0,25) had the strongest direct and total effect on WMIS for Water Management Decision-Making in the human dimension. Though some of the relationships between the constructs were new to the water management context, some of the remaining relationships were consistent with finding from other systems in the IS domain.

Further, the findings suggested that Service Quality, which in the contextual sense implied system and IT support staff, must be present onsite within the water management organisations to support WMIS users. Leaders in the various designations must have both and transactional and transformational characteristics. In this regard, they must ensure that they motivate users and commend them when they produce good work that affects the outcomes. Management should also ensure that they pay attention to external environmental factors like accreditation standards that affect their operations.

Finally, this research has provided empirical evidence of the development of an integrated WMIS success model that is based on IS models and water resources management principles.

DEDICATION

To the memory of my beloved grandfather, Opanin Kwabena Oduro Amoako.

To my loving grandma, [Queen Elizabeth] Maame Yaa Korang Donkor, who will forever be the light of my life.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AVE	Average Variance Extracted
CBSEM	Covariance Based Structural Equation Modelling
CFA	Confirmatory Factor Analysis
CMA	Catchment Management Agency
CMB	Common Method Bias
CMV	Common Method Variance
CRM	Customer Relationship Management
CSF	Critical Success Factors
CSIR	Council for Scientific and Industrial Research
CVR	Content Validity Ratio
DPSIR	Driving Force Pressure Impact State Response
DSS	Decision Support System
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWQRS	Drinking Water Quality Regulation System
DWS	Department of Water and Sanitation (South Africa)
EJIS	European Journal of Information Systems
ERP	Enterprise Resource Planning
eWQMS	Electronic Water Quality Management System
GIS	Geographical Information System
GPS	Global Positioning System
GWP	Global Water Partnership
HIS	Health Information System
HOT	FIT Human, Organisation and Technology Fit
HTMT	Heterotrait-Monotrait
ICT	Information and Communication Technology
IIOS	Internet-Based Interorganisational Systems
IMESA	Institute of Municipal Engineering of Southern Africa
IMQS	Infrastructure Asset Management Software
ISO	International Organisation for Standardisation
ITG	Information Technology Governance
IWRM	Integrated Water Resources Management
KMS	Knowledge Management System
LASCAD	London Ambulance Service Computer Aided Dispatch System
LIMS	Laboratory Information Management System
LVPLS	Latent Variable Partial Least Square
mHealth	mobile Health
MIMIC	Multiple Indicators, Multiple Causes
MIS	Management Information Systems
MISQ	Management Information System Quarterly
MTMM	Multitrait-Multimethod Matrix

NGO	Non-Governmental Organisation
NIWIS	National Integrated Water Information System
NWA	National Water Act (South Africa)
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PLS	Partial Least Squares
PM	Path Modelling
PMIS	Project Management Information System
PRP	Pipe Replacement Prioritization
RSA	Republic of South Africa
SALGA	South African Local Government Association
SANAS	South African National Accreditation System
SANS	South African National Standards
SCADA	Supervisory Control and Data Acquisition
SEM	Structural Equation Modelling
SEWSAN	Sewer Systems Analysis
SMS	Short Message Service
SWIFT	Sewsan and Wadiso Interface to Treasury
UNEP	United Nations Environment Programme
WADISO	Water Distribution and System Optimization
WATMIS	Water Management Information System
WDM	Water Demand Management
WHO	World Health Organisation
WMIS	Water Management Information System
WMO	Water Management Organisation
WRC	Water Resource Commission (South Africa)
WRM	Water Resources Management
WRMIS	Water Resources Management Information Systems

1 INTRODUCTION

The use of information technology in the management of water resources has risen over the past two decades (WEF, 2011). Information technologies have primarily been implemented to enhance everyday water management operations and functions, and decision-making challenges efficiently and effectively (Giupponi & Sgobbi, 2013; Souza, Hugo, Wensley, & Kuhn, 2009). Mongi and Meinhardt (2016, p. 104) state that “the role of ICTs for addressing challenges of shrinking water resources is as sound as the importance of water itself.” In water resources management, a collection of Information and Communication Technologies (ICTs), generally termed Water Management Information Systems (WMISs), have been implemented to enhance its effective management. Globally, WMISs have been implemented to support the operations, roles and functions, and decision-making processes that occur in water resources management (Abdullaev & Rakhmatullaev, 2014; Badjana, Zander, Kralisch, Helmschrot, & Flügel, 2015; Dent, 2010; Zander & Kralisch, 2016).

In particular, WMISs are central to the Integrated Water Resources Management (IWRM) process, which is the main framework for the management of water resources globally and in Africa. The IWRM process combines various dimensions of water resources management to ensure sustainable water resources utilisation within spatial and temporal domains (Borchardt, Bogardi, & Ibisch, 2016; Georgakakos, 2006; Pollard & du Toit, 2011). WMISs are the tools that enhance the entire process through its use implementation for the various functions, roles and outcomes associated with water resources management. The IWRM process faces challenges such the lack of integrated tools to support its planning and management, segmentation of institutional responsibilities for planning and management of the resource, limited stakeholder participation, and others. The IWRM process can be undermined by aspects such as the lack of integration and the other challenges stated earlier (Georgakakos, 2006). Well-implemented WMIS provide the relevant and needed support to the IWRM processes. These processes include functions and roles within the water management institutions, planning and operations, policy formulation and improvement, knowledge generation, and others.

Some of the uses of WMISs in the process range from monitoring the quality of water, pipe infrastructure planning, asset management, and others (EOH, 2015a; Herbertson & Tate, 2001; Rossouw, Botha, & Dlamini, 2005; Souza et al., 2009). These WMIS implementations have occurred at various levels – national, provincial, and local – of water resources management as established in the IWRM framework. They include bodies at the national level like the various departments, in the South African case for example, the Department of Water and Sanitation (DWS), and other regulatory bodies; Catchment Management Agencies (CMAs) at the provincial level; Water Management Organisations (WMOs), Water User Associations (WUAs), and others at the local levels. Severally WMISs have been implemented at these levels of water management to enhance management of its management

Further, stakeholders within water resources management rely on WMIS to obtain information for aspects such as decision-making and planning of the water infrastructure on a daily basis. Take South Africa as an example, the municipal government in the City of Cape Town needed relevant information from the WMISs, during the drought period between 2004 – 2005, to manage its water restrictions (Jacobs, 2008). Both the municipal and national government have also relied on WMISs to manage areas like its financing, water quality, water demand and others (Jacobs, 2008; Jacobs & Fair, 2012). A notable example is the Blue Drop System (BDS) that ensures the quality of South Africa's drinking water (Brown, Marsden, & Rivett, 2012; Rivett, Champanis, & Wilson-Jones, 2013).

The water management literature has reported varying successes with WMIS implementations at the various levels of water management and corresponding challenges (Abdullaev & Rakhmatullaev, 2014; Giupponi & Sgobbi, 2013; Rossouw et al., 2005). The success or failure of the WMIS implementation has been attributed to factors associated with the WMISs and the water management organisational contexts. In the past, the emphasis was placed on the WMIS with less attention given to the management and organisational components or factors (Rossouw et al., 2005). System factors have bordered on aspects such as the quality of WMIS (user-friendliness, ease of use, and others), and quality of the information in support of the functions and process (Souza et al., 2009). In the water management organisation context, some of the factors are associated with structure, environment and leadership (Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Fulazzaky & Akil, 2009; Giupponi & Sgobbi, 2013; Jacobs & Fair, 2012; Lincklaen, Wehn, & Montalvo, 2013; McDonnell, 2008; Schaub-Jones, Souza, & Mackintosh, 2014; Souza et al., 2009).

There have been calls in the water management literature to evaluate WMIS success in light of the studies that have outlined factors relevant to WMIS success, failure and challenges thereof (Mongi et al., 2016; Rossouw et al., 2005; Volk, Lautenbach, & Delden, 2009). To evaluate WMIS, there is the need first to understand the water management context – what water management entails?, approaches adopted for its management, institutional arrangements, roles and functions within the institutional arrangements, the WMISs implemented and their purpose, and constituents of their success or failure.

1.1 PROBLEM STATEMENT

WMISs employed at different levels of governance and water management globally and in South Africa (SA) have seen varying degrees of success and challenges. The focus has traditionally been on aspects of the WMIS such as the data collection, data management, and information generation and dissemination, and interoperability standards, with little consideration given to the management and organisational components. Primarily, the water resources management literature highlights mainly technical aspects of the WMISs employed to enhance the various functions, roles and decision-making (Anzaldi et al., 2014; Badjana et al., 2015; Dent, 2010; Rossouw et al., 2005).

However, water management as outlined in the IWRM process consists of roles and functions at different levels with varying data needs (Gerlak, Lautze, & Giordano, 2011; Quin, 2012; Timmerman, 2015). These roles and functions occur within the water management organisational structures and are also dependent on factors attributed to the external and internal organisational environment, and internal management that affects the entire process. The multi-stakeholder and multi-faceted nature of water resources management means an approach to understanding WMIS should entail both the technological, management and organisational components (Abdullaev & Rakhmatullaev, 2014; Grigg, 2016). Studies on WMIS success in the IS literature is presently lacking.

Existing literature points to the increasing role of WMISs for WRM and in particular its core role in the IWRM process. However, much of the literature in Africa emanates from the global perspectives and theoretical underpinnings. This has created gaps associated with studies on implementations, documentation and analysis of WMIS that enhance WRM in the African context (Otuke, 2016). Horne (2015) emphasises that many regions and countries globally have struggled to implement adequate WMIS to assist sustainable WRM. Having a sustainable water management regime relies on a successful WMIS implementation. Further, the successful implementation of WMISs is central to the IWRM process. This is because the functions and roles of the process, operations, governance, decision-making and many other aspects rely on effective information systems that provide relevant and timely data (Abdullaev & Rakhmatullaev, 2014; Borchardt et al., 2016; Dent, 2010; Georgakakos, 2006). However, there is a lack of understanding about what aspects of implemented WMISs and the IWRM framework makes it successful (Georgakakos, 2006; Giupponi & Sgobbi, 2013; McCartney, 2007). This lack of knowledge undermines the effectiveness of achieving the outcomes of IWRM within the water management institutions (Aher, Adinarayana, Gorantiwar, & Sawant, 2014; Georgakakos, 2006; Giupponi & Sgobbi, 2013).

This study tackles WMIS success from a quantitative perspective by developing a WMIS success model that integrates the organisational and technical aspects of the Water Resources Management institutional setup. The aim is to develop a model to understand WMIS success through the organisational and system factors.

The section that follows poses research questions aimed at understanding WMIS success for efficient water resources management.

1.2 RESEARCH QUESTIONS

The study is then guided by the primary research question:

RQ: What system and organisational factors can be used to develop a model for WMIS success that supports efficient water resources management?

To answer the question above, the following specific research questions will guide the research:

RQ 1. What organisational factors affecting the organisation's functions determines WMIS success?

This research question provides an understanding of the water management context – roles and functions, institutional arrangements, information needs within the institutional arrangement and others.

RQ 2. What system factors determine the success of Water Management Information Systems?

The purpose of this question is to gain an understanding of the underlying system factors that affect the success of WMIS in a water resources management context. This question is fundamental in obtaining the system factors for the WMIS success model to be obtained.

RQ 3. What IS success models can be used to derive a WMIS success model?

This question will provide an understanding of what IS models can be used to develop a WMIS success model. The question provides insight into the relevance, purpose and applicability of IS models. This research question is answered in Chapter 3 of this research.

1.3 APPROACH TO THE RESEARCH

Drawing on theories from the extant IS and water management literature, the study developed a model for WMIS success based on system factors related to the WMIS and organisational factors associated with the roles and functions at different water management levels in South Africa. The model extended models from IS with the addition of three new constructs – WMIS for Water Management Operations, WMIS for Water Management Decision-Making and Leadership – that will be justified in Chapter 3.

To test and validate the model developed, cross-sectional data were collected via a questionnaire survey. As can be seen in Figure 1-1, the research instrument (questionnaire) development and validation, data collection and validation occurred in three phases (Lewis, Templeton, & Byrd, 2005; Urbach & Ahlemann, 2010). The first phase involved construct specification from the IS and WRM literature, construct definitions and item generation. The second phase was for the pre- and post-testing, pilot and instrument validation. In the third phase, the data collection and validation followed with the survey instrument(questionnaire) and validation of the instrument. A total of 267 WMIS users assigned to varying designations from the City of Cape Town's Water and Sanitation Department participated in the survey.

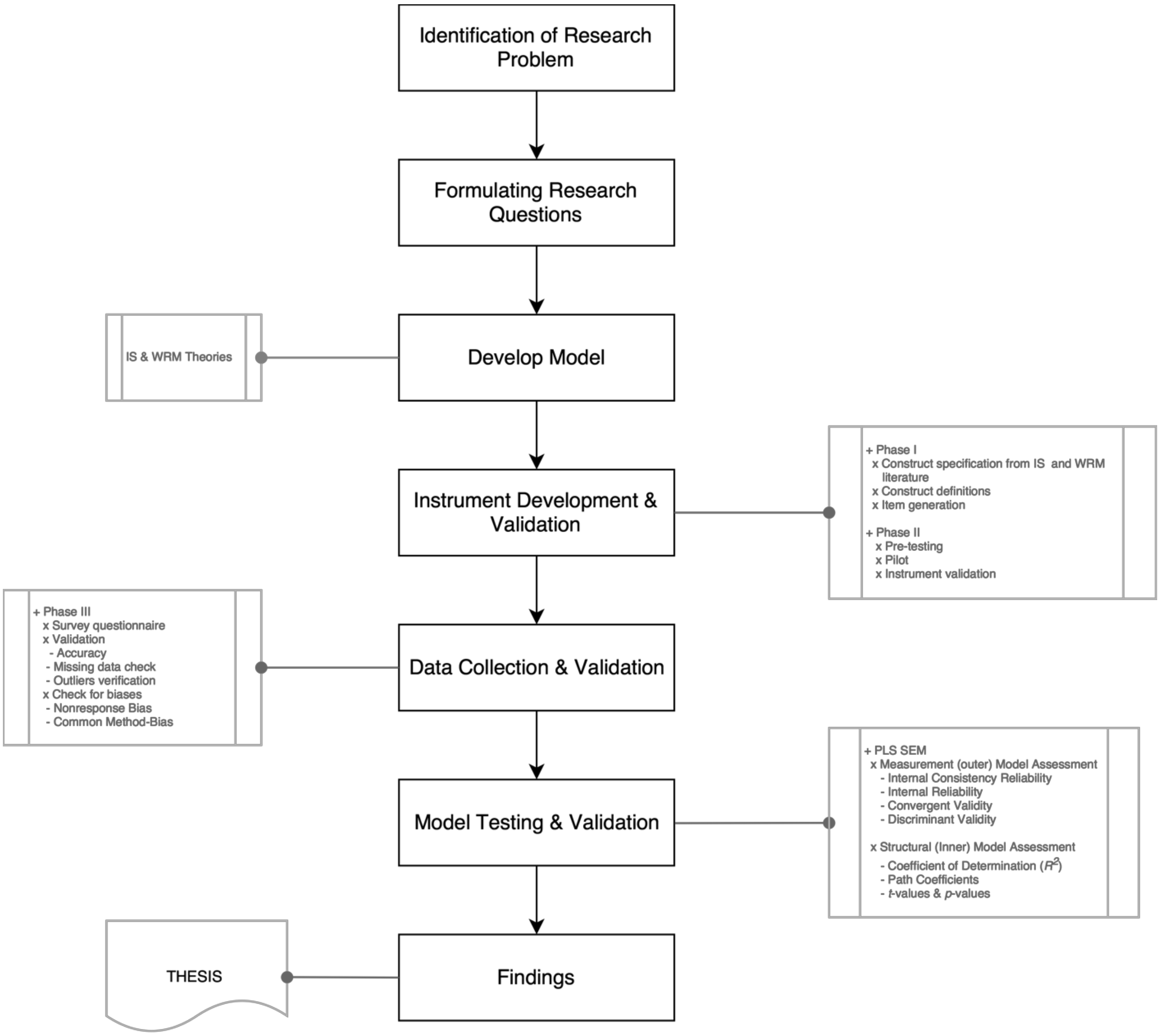

Figure 1-1: Flowchart of the Research Approach

To analyse the data from the survey, a Partial Least Squares (PLS) approach to Structural Equation Modelling (SEM) was employed (Hair, Ringle, & Sarstedt, 2011; G. Sanchez, 2013; Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). The PLS SEM approach has some steps taken to ascertain the validity of the measurement(outer) and structural (inner) models.

The approach to the study presented above aligned strongly with a positivist stance based on previous studies in the IS domain. The findings of the research are then presented.

1.4 RESEARCH CONTRIBUTIONS

This study contributes theoretically and practically to the IS and water management domains.

1.4.1 Theoretical Contributions

The first theoretical contribution of the study was a model for explanation and prediction of WMIS success which is the first to be developed and empirically validated in the IS domain. A further contribution is the application of Integrated Water Resource Management (IWRM) principles, leadership theory as applied to IWRM, and IS success models in the model explanation and prescription for the South African and in particular a developing country context. This understanding does not exist in previous IS and water management literature, and in the water management and South African context. Hence, this study becomes the first to provide such an understanding in this context.

1.4.2 Practical Contribution

This study will strengthen water resources management practice. Water managers, practitioners and stakeholders will find the model as a resourceful tool in their understanding of the organisational and system factors affecting WMIS success and hence plan accordingly to enhance efficient water management. Particularly, recommendations regarding the service quality of the WMIS, organisational leadership and the environment should be implemented for efficient water resources management.

1.5 THESIS OUTLINE

The outline of the thesis is as follows.

Chapter One: Introduction

This chapter introduces the study and motivates why the research is being undertaken. The scope of the study, the problem statement, research questions, the approach that was taken to achieve the research objectives, research contributions and the outline of the thesis are presented.

Chapter Two: Water Resources Management

This chapter discusses concepts of water resources management, challenges associated with its management, approach – Integrated Water Resources Management (IWRM) – taken to address the challenge. The case of IWRM in South African is then discussed. The approaches to water management challenges introduced are heavily reliant on water information. Thus, information and information management in water resources management are discussed. This section discusses in detail the need for information in water resources management, the information sources at the different water management levels, and information needs for the approaches taken to solving the water management challenge. Management of the information is highly relevant, and hence information management is discussed. Information systems for management of the information are then discussed. The concept of Water Management Information Systems (WMIS), and how it supports WRM functions and decision-making is discussed.

Chapter Three: Theoretical Background of the Model

This chapter presents the theoretical background of the proposed WMIS success model. I discuss the success and failure of WMIS, WMIS evaluation and its constituents as presented in the water management literature. I then proceed to discuss IS success evaluation models and then introduce the HOT-Fit Framework, and the DeLone and McLean IS Success models which form the basis for the proposed model. I introduce organisational concepts which were informed by the water management principles discussed in the previous chapter.

Further, the theoretical background in relation to WMIS success – DeLone and McLean IS success model, HOT-Fit Framework, Leadership theory, organisational structure and environment – are discussed. Finally, the chapter ends with research gaps and opportunities, and summary.

Chapter Four: Development of the Model

This chapter discusses the development of the WMIS success model. The justification for the selection of the model bases and each of the constructs are explored. They are discussed in terms of the human, organisation, technology dimensions that affect WMIS success via WMIS for Water Management Decision-Making and WMIS for Water Management Operations. It continues with the operationalisation of the model constructs. The conceptual model is finally presented with a set of hypotheses to be tested in order to validate the model.

Chapter Five: Research Methodology

The chapter presents the research methodology. The different IS epistemological stance and justification for this study is presented. The chapter further discusses the development of the research instrument – construct specification and item generation, instrument development, item scaling, pretesting of instrument, pilot study, content validity – employed in the study; data collection – data collection strategy, follow-up procedures, survey response rate; data validation – data accuracy, missing data check, outliers verification; checking for biases – nonresponse bias, common method bias; validation of model – indicator (item) reliability, internal consistency reliability, convergent validity, and discriminant validity; and the data analysis techniques – structural equation modelling and its application to the research. The chapter ends with ethical considerations.

Chapter Six: Analysis of Results

In this chapter, the results of the data analysis using the techniques outlined in the research methodology are presented. The summary statistics and findings on the biases introduced in chapter four are discussed. The results of the measurement (outer) and structural (inner) models are finally presented.

Chapter Seven: Findings, Discussions and Conclusions

The final chapter discusses the findings of the research regarding how it answered the research questions; implication to both theory and practice; limitations of the research; and suggestions for further study. The chapter finally discusses the conclusion of the entire research.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The chapter begins with a review of water resources management that is relevant to the study. I introduce the concept of water resources management and then I proceed to discuss IWRM as an approach to water resources management. The discussion will continue with how the IWRM approach has been applied to the South African context. The functions, responsibilities and institutional structures are discussed. The information needs and flow of the information in the IWRM process are also addressed. I then look at the role of IS in WRM and particularly WMIS. The chapter proceeds with WMIS in support of the functions and responsibilities outlined. I finally discuss the implementation and success of the WMIS within the WRM.

2.2 WATER RESOURCES MANAGEMENT (WRM)

Grigg (2008b, p. 58) defines WRM, which this study adheres to, as "Water resources management is the application of structural and non-structural measures to control natural and man-made water resources systems for beneficial human and environmental purposes." The concept of WRM is often interchanged with water management in literature to highlight management of the resource and not just the movement of the water through pipe systems (Grigg, 2008b). Structural measures consists of physical constructions such as conveyance systems (pipes, canals and channels), treatment plants, pumping stations and others to control water flow and quality, whereas non-structural measures consists of programs or activities which are not constructed such as pricing schemes, incentives, public communication or relations, regulatory programs and others (Lehr, 2005). These occur within a setup that consists of water service organisations, coordinators, allocation and other supporting institutions or organisations (Abdullaev & Mollinga, 2010; Lehr, 2005).

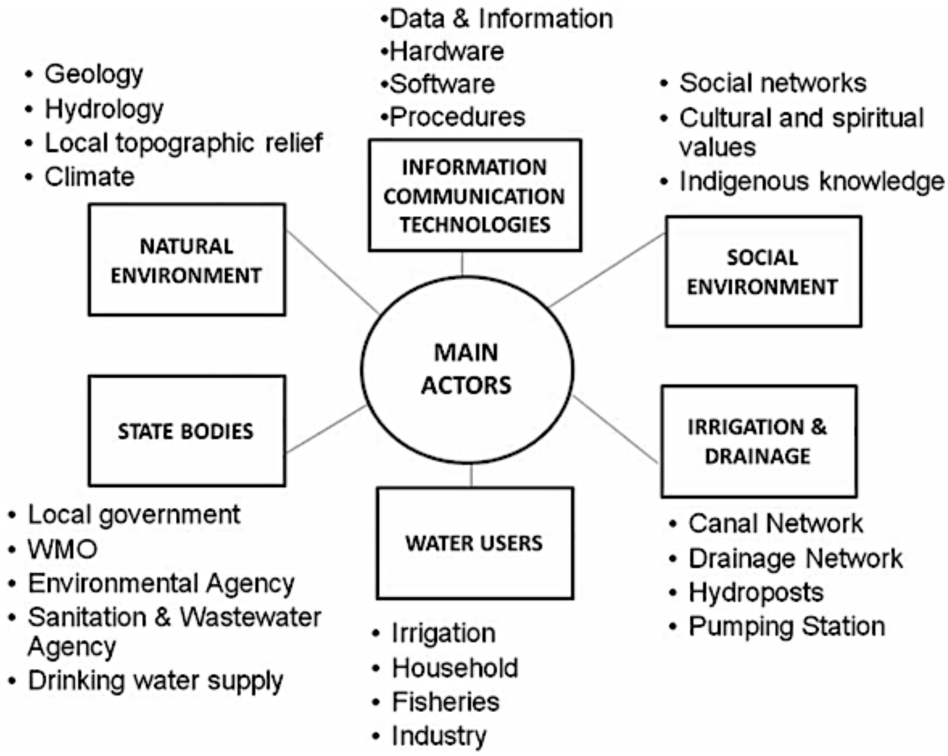

Figure 2-1: Actors in water management (Abdullaev & Rakhmatullaev, 2014)

Much like the structural and non-structural measures, Abdullaev and Rakhmatullaev (2014), provide six actors engaged in daily water management as shown in Figure 2-1. The six actors – natural environment, state bodies, water users, irrigation and drainage, social environment and information and communication technologies – which interact and are interdependent, shape the decision-making process and water management functions in the water sector. The decision-making process in the water management sector is shaped by interactions and interdependencies between these actors – human and non-human.

The management of water resources is critical for food and ecological security, and overall human development. However, there is mismanagement of the resource due to challenges that arise particularly in developing countries (Freitas, 2013; Molobela & Sinha, 2011). This is so due to the number of challenges that arise (Cosgrove & Loucks, 2015; Molobela & Sinha, 2011; Timmerman, 2015). There is the challenge of water scarcity due to limited availability. In South Africa, this challenge is compounded due to low annual average precipitation, and the effect of climate and geographical parameters that causes unevenness in the distribution of ground and surface water (Molobela & Sinha, 2011). In general sub-Saharan Africa lags behind most regions of the world regarding water access, supply and management (Freitas, 2013).

The quality of water and related compliance also presents a challenge (Pitman, 2011; van Rooyen, de Lange, & Hassan, 2011). In this regard, much attention has to be given to the monitoring of water quality and South Africa seems to have implemented systems that enhance the monitoring of water quality. Other aspects such as equity and distribution of the resource which has historical roots have also been a challenge (Molobela & Sinha, 2011; Pollard & Toit, 2008; van Rooyen et al., 2011).

Given that the resource is distributed unevenly in space and time (Giupponi & Sgobbi, 2013; Nsubuga, Namutebi, & Nsubuga-Ssenfuma, 2014) and its management has many facets, an approach to its management that traverses disciplines, recognises the relevance of the local context, acknowledges the inherent complexities of the organisations that manage the resource and the existing linkages across disciplines and between various organisations, and is comprehensive is required (Abdullaev & Mollinga, 2010; Grigg, 2008a; Lehr, 2005; Simonovic, 2009). As Grigg (2008b, p. 14) puts it, "Water management is a shared challenge", and this brings to the fore why its management needs an approach that combines the various disciplines and stakeholders.

Integrated Water Resources Management (IWRM), an approach to water management that supports the aforementioned aspects and has been adapted as the basis for water resources management in different parts of the world including South Africa (Agyenim & Gupta, 2012; Anzaldi et al., 2014; Funke, Oelofse, Hattingh, Ashton, & Turton, 2007; Hu et al., 2014; Jonker, 2007; Karthe et al., 2015), is presented next.

2.3 IWRM AS AN APPROACH TO WATER RESOURCES MANAGEMENT

The Global Water Partnership (GWP[1]) definition of Integrated Water Resource Management (IWRM) is stated as the "process which promotes the coordinated development and management of water, land, and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Hering & Ingold, 2012, p. 1234; Karthe et al., 2015, p. 3487). The aim is to have a holistic perspective on the management of water resources(Suhardiman, Clement, & Bharati, 2015).

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[1] www.gwp.org

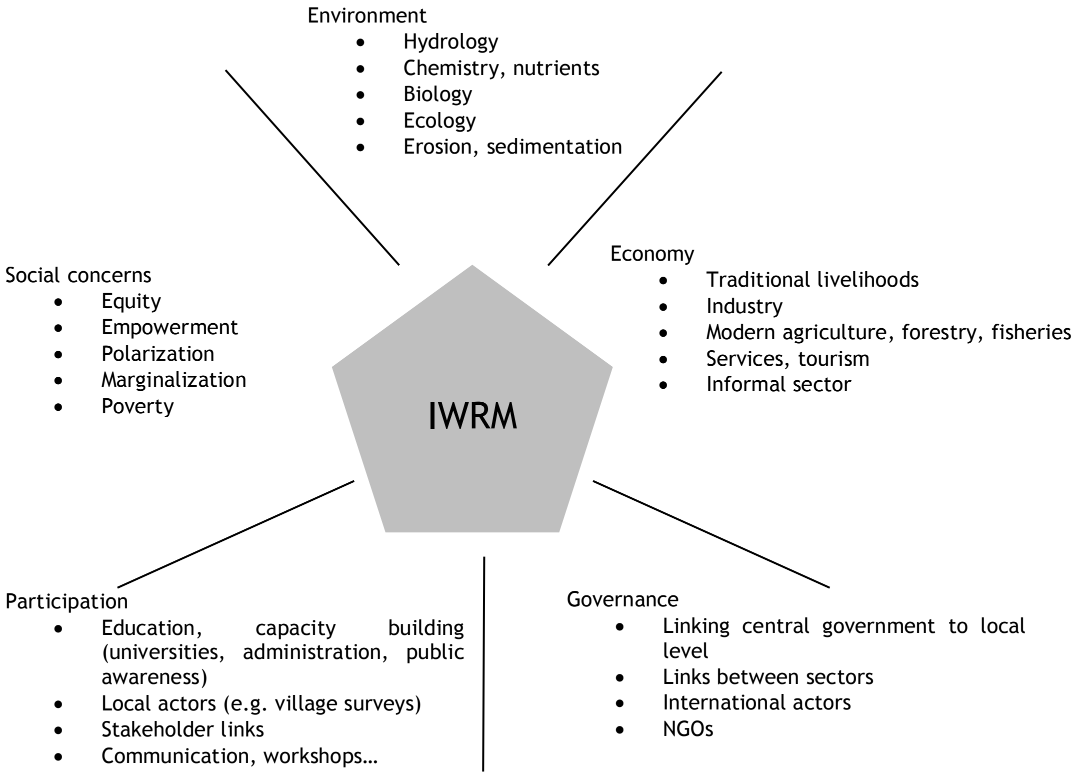

Figure 2-2: Dimensions of IWRM (Varis et al., 2006)

As seen in Figure 2-2, IWRM attempts to holistically manage water resources by combining dimensions associated with the environment, economic and social concerns, governance and participation from various stakeholders.

Within the environment, there is the need to understand the ecosystem functions and tools for the prediction of impacts that have to do with developments. Water management involves various disciplines, and as seen there should be a delicate balance to achieve this aim. That includes having the relevant skill and manpower to address these aspects (A. Anderson, Karar, & Farolfi, 2009; Varis et al., 2006).

Participation from both public and private stakeholder form an essential aspect of the IWRM process. Effective engagement requires strategic planning to ensure the outcomes of such participation are applicable and relevant to the implementation.

These involve education, capacity development, creating public awareness, involving local actor and champions, and finding means of effective communication all the engagements. The engagements and participation should be tailored at the respective level of implementation. As an example, there will not be a need to necessarily engage the public in processes which are technical by nature and require specialised information and expertise (A. Anderson et al., 2009).

Good governance is also pre-requisite of the IWRM process. It involves some distinct elements for which decision-making is critical. It is an essential part of the entire institutional framework that supports IWRM. Here, the emphasis is placed on the institutional environment at national, provincial and local levels and the legislation that guides stakeholders in their various roles in the management process (Funke et al., 2007).

Integration is paramount to the concept, however, the practicality of what is to integrated raises questions (Suhardiman et al., 2015). Researchers, water experts and stakeholders strongly believe that for IWRM to be successfully implemented, the ambiguities – “land-related resources”, “maximization”, “equitable”, “sustainability”, “economic and social welfare” and others – surrounding the concept must be well-defined (Asit, 2008; Hering & Ingold, 2012).

The above shows how the various dimensions combine to bring about a holistic approach to water resources management. A combination of these different aspects across different disciplines naturally raises challenges and questions on how feasible it is to implement IWRM. Amidst the criticism on implementation feasibility and challenges, and the aim to properly conceptualise IWRM, the concept has perceived positives and benefits (Butterworth, Warner, Moriarty, Smits, & Batchelor, 2010; Medema, Mcintosh, & Jeffrey, 2008; Suhardiman et al., 2015). The benefit of IWRM is its provision of a holistic framework that brings together the contributions of water users, policymakers and other stakeholders, and research from the broader research community across varying disciplines (Medema et al., 2008).

Figure 2-2 provided this holistic view of what IWRM entails, and Grigg (2008a) moves further to propose the list of elements to be integrated. These elements are the policy sectors, water sectors, government units, organisational levels, functions of management, geographic units, phases of management, and disciplines and professions. These elements speak to the facets involving the various water management actors discussed in the previous section.

IWRM has guided water management globally and particularly South Africa (Agyenim & Gupta, 2012; Funke et al., 2007; Jonker, 2007; Movik, Mehta, van Koppen, & Denby, 2016). In South Africa, IWRM has seen the progressive devolution of water resources authority and responsibility to Catchment Management Agencies (CMAs) (DWA, 2007; Pollard & Toit, 2008). The sections that follow discuss water management in South Africa.

2.4 THE IWRM APPROACH IN SOUTH AFRICA: THEORY AND PRACTICE

There have been significant changes in water resources management particularly in the management structure, functions and responsibilities, legislation and policies, and their allocation post-apartheid (Bourblanc & Blanchon, 2014; Lindfors, 2011; Molobela & Sinha, 2011). The understanding of the devolution of IWRM in South Africa is essential for the context of this study.

The sections that follow discuss the legal basis – water policy and legislation, the institutional framework, and the roles and functions of the South African water sector.

2.4.1 Policy and Legal Context of Water Provision in SA

Provision of water and management of the resource in South Africa is backed by three legal documents; the Constitution of the Republic of South Africa (1996), the White Paper on National Water Policy (1997), and National Water Act (NWA) (1998). Access to water is enshrined first in Section 27 (1) (b) of the South African Constitution (RSA, 1996). The constitutional backing led the way for the provision and promulgation of other laws and frameworks to guide the water sector.

In 1997, the then Department of Water and Forestry (DWAF) of South Africa produced a White Paper on National Water Policy (DWAF, 1997). It aimed at legislating the municipal function of the provision of water supply and sanitation services. Further to this, the South African Government promulgated the National Water Act (Act No. 36) in 1998 (RSA, 1998a). The guiding principle was the protection, use, development, conservation, management, control and sustainable utilisation of South Africa's water resources (DWAF, 2005a; RSA, 1998a; Western Cape Government, 2011). Notably, it provided details on water management strategies, regulatory procedures, structural guide, the delegation of roles and duties, standards and tools and designation of institutions for the integrated approaches emphasised management of the resources in the National Water Policy (Karodia & Weston, 2000; Lindfors, 2011).

These policies and legislative frameworks together with others like the National Environmental Management Act (Act 107 of 1998), Local Government: Municipal Demarcation Act (Act 27 of 1998), Local Government: Municipal Structures Act (Act 117 of 1998), Local Government: Municipal Systems Act (Act 32 of 2000), Local Government: Municipal Structures Amendment Act (Act 33 of 2000), National Water Resource Strategy have provided the legal framework and foundations that have shaped water resources management in South Africa (DWA, 2013; Rivett et al., 2014).

2.4.2 Functions, Responsibilities and Institutional Structures

There are three spheres of government in South Africa: the national, provincial and local (municipal) governments. The WSA and NWA outline the different institutions and related roles and functions which have to be performed at the various levels as shown in Figure 2-3. The provision of water services is a responsibility of local government in South Africa. The responsibility of providing water services, however, lies with the districts and metropolitan municipalities regarding Section 84 of the Municipal Structures Act. The national and provincial governments are responsible for ensuring that responsibilities assigned to the Water Service Authorities within the local government are performed accordingly. The WSAs also delegate delivery of water services to other Water Service Providers (WSPs), who can either be a government body, a private entity or a community-based organisation (Lindfors, 2011).

Whiles some overlap, a few are the reserve of specific authorities. Each of the institutions has a responsibility to develop various plans and strategies (RSA, 1998a; Western Cape Government, 2011). In the sections that follow, the responsibilities of each of the institutions as depicted in Figure 2-3 will be thoroughly discussed.

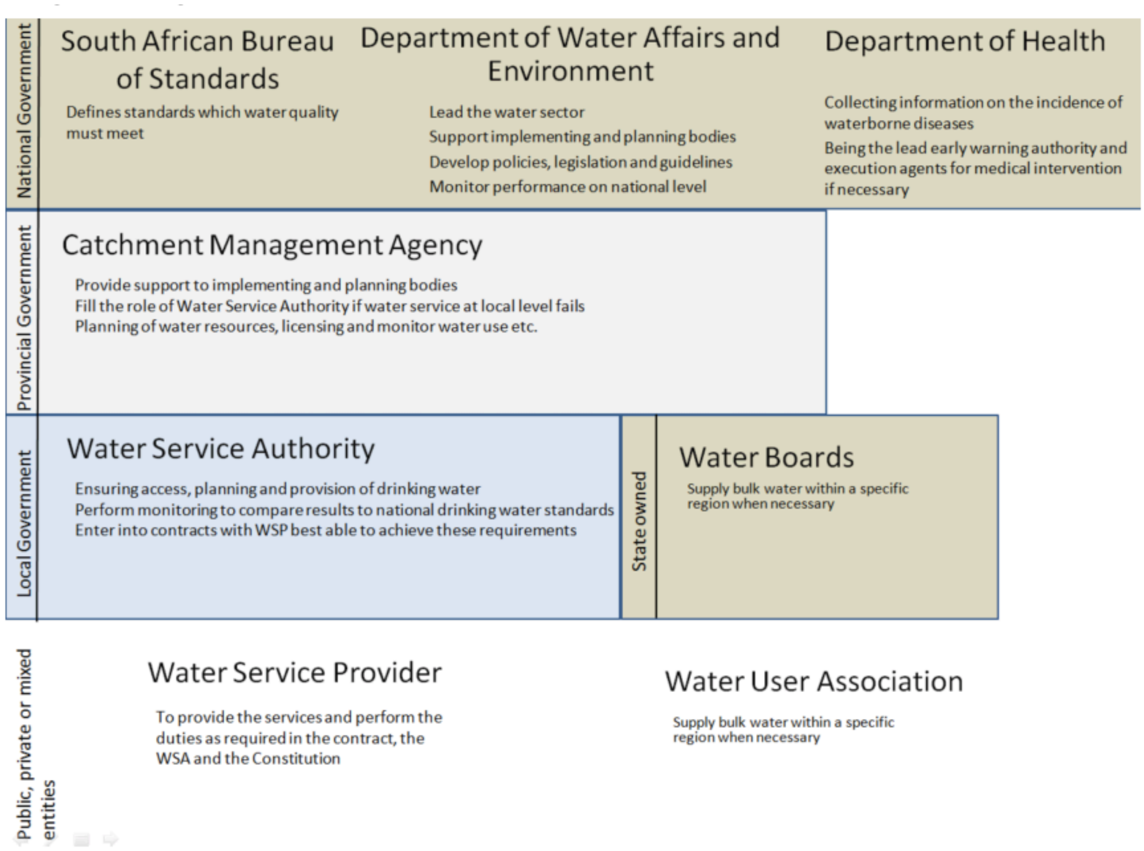

Figure 2-3: Institutional Arrangement of Water Resources Management (Lindfors, 2011)

The discussion of these functions, roles and responsibilities at the various levels provides the study with the understanding of the interdependencies between actors that have been discussed earlier in the section on WRM. Again, this sets the stage for understanding information flow and requirements for information and communication technologies implementation.

2.4.3 Department of Water and Sanitation (DWS)[2]

The Department of Water Affairs and Sanitation, headed by the Minister of Water and Sanitation, is the national body that serves as the custodian or trustee of water resources in South Africa. It forms the first tier of the South African water resources management structure (DWAF, 2005a, 2005b). As the national body, the DWS is responsible for overseeing and administering all the aspects of the NWA which the Minister or Director-General assigns it. It must ensure that policies and tools that govern the sector are formulated and well implemented, development of new or maintenance of existing water resources infrastructure, adhere to various regulations, issuing of water use licenses, management of water information, and integrated water resources planning and others (Lindfors, 2011; Western Cape Government, 2011). Standards, such as water quality and others, at this tier of water management, are defined by the South African Bureau of Standards (SABS).

2.4.4 Water User Associations (WUAs) and Water Service Authorities (WSAs)

Water User Authorities, Water Service Authorities and Water Service Providers (WSPs) make up part of the third tier of water management governance. The primary aim of these specific groups are of water use management rather than management of the resource though they can be empowered to do that (Western Cape Government, 2011). Their operations occur at the local level of water governance, and it involves individual water users or groups that undertake water-

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[2] It was previously known as the Department of Water Affairs/Department of Water Affairs and Forestry.

related activities to benefit the collective in a mutual manner (DWAF, 2005b). They are also established to as mandated by the NWA to manage the local water infrastructure and to implement management decisions that are agreed on between various members of the designated area (Karar, Mazibuko, Gyedu-Ababio, & Weston, 2010).

2.4.5 Catchment Management Agency (CMA)

Catchment Management Agencies form the second tier of water resources management (DWAF, 2005b). They were established regarding section 78 (1) of the NWA with one of the main aims being the decentralisation of water management to allow for public participation (Bourblanc & Blanchon, 2014; Meissner, Stuart-Hill, & Nakhooda, 2017). The first responsibility of CMS is the development and implementation of a Catchment Management Strategy (CMS). This serves as the water management framework of the WMAs in its area of jurisdiction. Further, it has oversight responsibility for the institutions and organisations below it, such as the water user associations (Karar et al., 2010). In this respect, CMAs must ensure that water within the WMA is managed in a sustainable, efficient and equitable manner.

Stakeholder participation and public involvement in water management are crucial in the integrated management approach. CMAs have an essential responsibility of coordinating the activities of stakeholders and developing the necessary institutional arrangements for participation and empowerment in its management (Karar et al., 2010).

Interactions that occur between the various institutional arrangements at the different government tiers involve a substantial amount of information and knowledge sharing, and a feedback mechanism for continuous water management and decision-making (Western Cape Government, 2011). Relevant actors and stakeholders require information for the everyday operations and decision-making, as well as for long-term and sustainable management of the resource. More importantly, the NWA considers the management of information on water resources as critically important for the achievement of the roles and functions designated at the various levels of water management. The Act mandates for information management and the establishment of information systems to manage the information (RSA, 1998a, Chapter 14). Establishment of information systems require the relevant quality checks on both the system and information thereof. It will be seen later in this study how the quality of the system and information affects the overall outcomes.

2.5 ROLE OF INFORMATION AND INFORMATION MANAGEMENT IN WATER RESOURCES MANAGEMENT

2.5.1 Water resources management and the need for information

Decision-making and daily operations in water resources management require data from different levels of water management and also need coordination across a spectrum of disciplines as seen from the discussion earlier. At the core of the IWRM process is integration (Claassen, 2013) and the information is continually being exchanged. The role of information in water resources management is mainly to support the efficient and effective decision-making process at various levels of water management for distribution of the resource equitably and transparently (Jacobs & Fair, 2012; McDonnell, 2008; Welle, 2010). The effective, efficient and transparent management of water resources globally is thus dependent on information acquisition and sharing across various national, regional and local levels, and among stakeholders across multi- and trans-disciplinary fields (Curry et al., 2014; Rivett, 2012; Soto-Garcia, Del-Amor-Saavedra, Martin-Gorriz, & Martínez-Alvarez, 2013; Welling, Cartin, Baykono, & Diallo, 2012).

The need for reliable information for effective water resources management and provision of such information in a timeous manner is central in the decision-making process (Borchardt et al., 2016; Gerlak et al., 2011; McDonnell, 2008; Timmerman & Langaas, 2005). Baisch (2009) confirms that data is the basis of sustainable water resources management planning. There has been a steady increase in the need for information to manage the resource over the past few years (Timmerman, 2015). However, the lack of water information hampers the management of water resources by stakeholders at all levels of water management globally (Messervey, Perfido, Hannon, & Smit, 2015).

Information generated from the data acquired from the WRM process is relevant in evaluating several aspects of water management. For instance, it forms the basis for evaluating and understanding the effects of specific and formulated policies (Timmerman, 2015), assessing performance and regulatory issues (Souza et al., 2009), managing water use and demand (Kossieris, Panayiotakis, Tzouka, Gerakopoulou, & Rozos, 2014), addressing water quality issues (Rossouw et al., 2005; Souza et al., 2009), day-to-day operations and other important matters pertaining to WRM (McDonnell, 2008). Thus, any attempt at evaluating or understanding WMIS should include aspects related to data such as its quality and how this data affects the overall outcomes.

2.5.2 Information Cycle Model and Water Management

At the various levels of water management and governance, the inherent processes are bound to the information cycle shown in Figure 2-4 (Timmerman, 2015). Timmerman (2015) distinguishes the elements within the information cycle (IC) as it moves from information requirements to obtaining the information. The first element is the link between water management and information production process.

Information needs should be decided by both information producers and information users. These needs include the characteristics of the information. Following on, information producers in co-operation with information users should again decide on a strategy for information collection that meets quality and other standards most efficiently and cost-effectively.

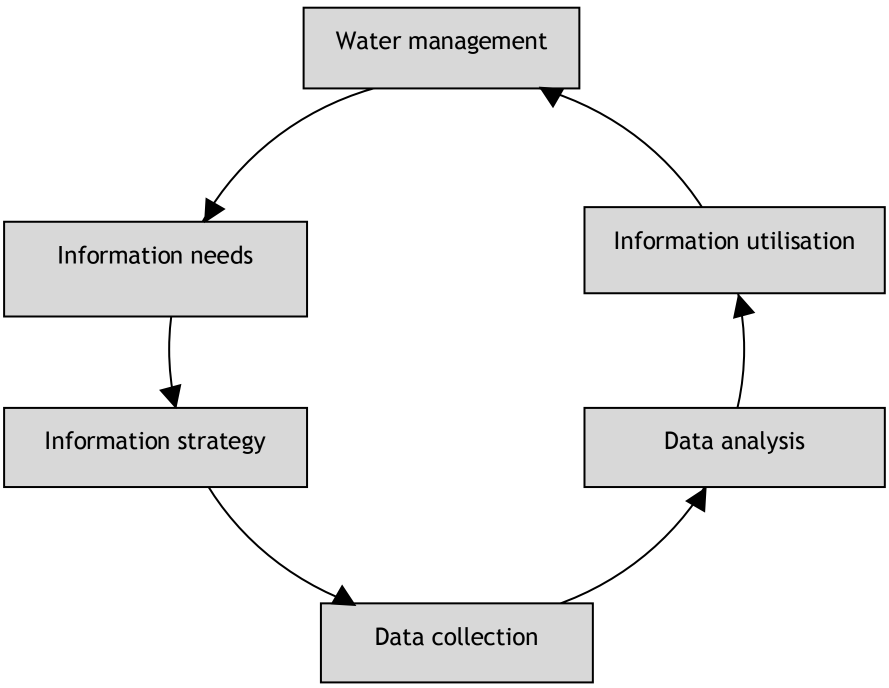

Figure 2-4: The Information Cycle

Again, the type of data and information need determines how the data collection is done. This is a critical step in the IC process. Once data collection is done, analysis of the data obtained is next. At this stage, the analysis is the needs set out in this case by stakeholders and other decision makers. The final stage in the process is the presentation of the resulting information to the users. The author states that at this stage, there is a link between the management of water and science in the utilisation of the information produced. As Choo (1995) argues, the use of information is an interactive social process of inquiry which is dynamic, the result of which may be the making of meaning or decision making. In summary, different users and stakeholders tasked with management of resources have different information requirement (Curry et al., 2014). The next section discusses information needs within the IWRM processes.

2.5.3 Information Needs and Flow in the IWRM Processes

As discussed in Section 2.2, IWRM and transboundary water management are complex with many stakeholders involved at different levels (Timmerman & Langaas, 2005). Access to water resources information is known to be essential particularly in such a setting, given the need to continually share information.

Information exchange is a fundamental component of IWRM. It is essential for the enhancement of cooperation and agreement formation, immediate areas of disagreement, and in bringing about coordinated management (Gerlak et al., 2011). Abdullaev and Rakhmatullaev (2014) posit that access to information for both the public and policymakers promotes IWRM principles which augur well for a more participatory approach to management of the resources.

As seen in the sections on approaches to water management, it is acknowledged that the availability of information and management of the information is of crucial importance to both IWRM. There should be the availability of information and conscious collection of new information as well as its monitoring. Information processing and the desired change must be open and understandable to all relevant stakeholders. Its management, however, can bring about challenges since the various stakeholders at the different levels – national and local – who are responsible for the data collection and analysis often have different norms, values and beliefs (Nilsson, 2003). Data and information have been handled hierarchically from the local to the lowest to the highest levels of water management within the water sector (Abdullaev & Rakhmatullaev, 2014).

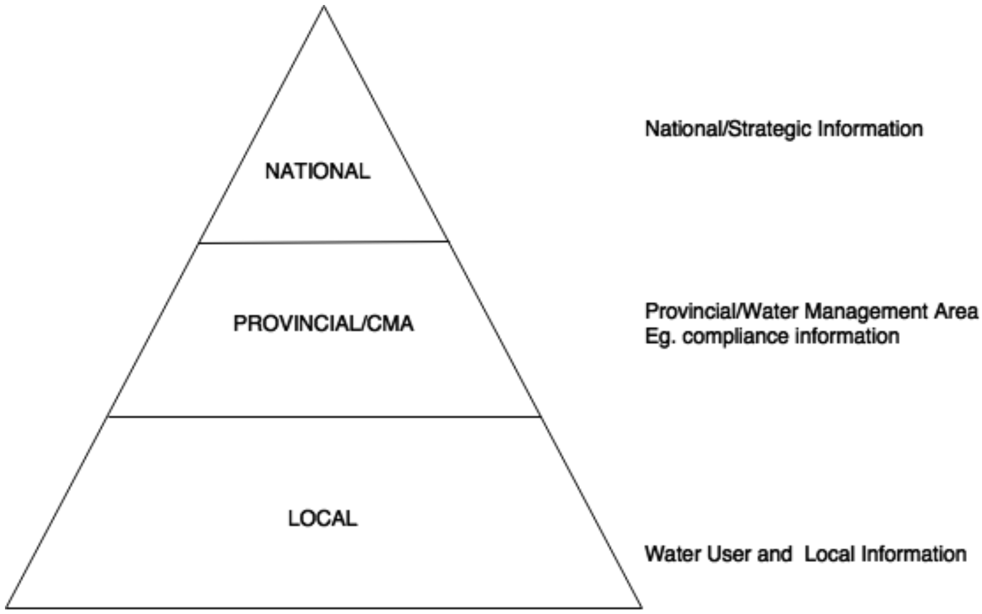

Figure 2-5: Information flow hierarchy among stakeholders (Nepfumbada, Braune, & Madikizela, 2005)

At the highest level of IWRM, strategic information is a need for the oversight responsibilities, monitoring and evaluation at the policy management and regulations. Information flows from the provincial level through to the national. At the provincial level, information related to the management of the resource, stakeholder coordination, standards, and other roles and responsibilities enhances the operations and decision-making processes. At the lowest hierarchy, local water information on water use is required (Nepfumbada et al., 2005).

This multi-stakeholder need for information and sharing in present IWRM management is highly reliant on information and communication technologies (Miller, Guertin, & Heilman, 2004). These ICTs must be reliable, easy to use, user-friendly, effective in its data management, provide accurate data for relevant decision-making and a host of other attributes releveant to the roles and responsibilities (Abdullaev & Rakhmatullaev, 2014; Miller et al., 2004; Souza et al., 2009). In the sections that follow, I will thoroughly discuss ICTs as one of the actors in the IWRM process, the specialised ICTs being employed in the various roles and the decision-making process at a later stage.

2.5.4 Information Ownership in the IWRM Process

The discussions in the prior sections have shown the nature and importance of information in the decision-making processes of the IWRM. However, the collection of data and subsequent information creation within a complex and multi-faceted setup such as WRM brings administrative challenges. These challenges have in some instances affected the water management institutions' ability to integrate aspects such as decision-making (McDonnell, 2008). Examples are departments within and across the WRM divide that are reluctant to share data due to administrative and political struggles within an organisation. Inconsistencies arise although all stakeholders understand the importance of sharing information (Abdullaev & Rakhmatullaev, 2014; Thu & Wehn, 2016).

Good practice in the IWRM process relies heavily on the co-ordination, co-operation and sharing of data collected at various levels and across the water domain (Plengsaeng, Wehn, & van der Zaag, 2014). Therefore, stakeholders involved must ensure data ownership is addressed. In this regard, the following should be clarified: who are the data providers and who needs the data; what structures need to be in place to support data sharing; what standards, mechanisms, and frameworks need to be applied to the data; who pays for the data collection cost and what is the time scale of relevance; who is legally responsible for managing the accuracy and currency of the data (McDonnell, 2008; Plengsaeng et al., 2014; Thu & Wehn, 2016).

These essential questions affect the quality of the information system regarding its overall outcomes associated with their implementation.

2.6 INFORMATION SYSTEMS (IS) IN WATER RESOURCES MANAGEMENT

2.6.1 Introduction

The operations and decision-making processes at every level of water resources management rely on varying information communication technologies. From GIS tools, water quality monitoring software systems, water distribution planning software systems, statistical analysis tools and other systems – hardware and software, these ICT tools have been used to enhance the water resources management processes. They have been known to play an essential role in mitigating some of the challenges that arise in WRM (Anzaldi et al., 2014; Giupponi & Sgobbi, 2013; Rivett, 2012; Rossouw et al., 2005).

2.6.2 Water Management Information Systems (WMIS)

Water Management Information System (WMIS) is a combination of technological resources and tools implemented for water resource management. They are ICTs implemented to enhance the operations and decision-making process, which form the core mandate of water management organisations. ICT has been integrated into WRM in varying forms. They are sometimes referred to as Water Resources Management Information Systems (WRMIS) (Rossouw et al., 2005). , Horne (2015) state that a country's WMIS will in part reflect the responsibilities and roles established in its institutional and legislative framework. According to Rossouw et al. (2005), most WMIS consists of at least three core functional components – data acquisition, data storage and management and information generation and dissemination. A fourth component which deals with knowledge products is considered relevant to the decision-making process (Rossouw et al., 2005). WMIS range from business systems for Enterprise Resource Planning (ERP), customer information systems, Infrastructure Management Systems (IMQS) to planning and operation systems such as Supervisory Control and Data Acquisition (SCADA), Geographical Information Systems (GIS), Laboratory Information Systems (LIMS), Hydrological Information System (HIS) and Decision Support Systems (DSS) (Harris, Howman, Grobler, Kühn, & Ntsaba, 2001; WEF, 2011; Wienand, Nolting, & Kistemann, 2009). WMISs provide immense support for the entire water management process. Of interest to this study is the supporting role WMIS plays in the everyday operations and decision-making aspects of water management. The implementation of WMIS for operations and decision-making in water resources management has been highlighted in the literature as one of the essential aspects the entire management processes (Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Rossouw et al., 2005).

Many countries globally are implementing or have plans to implement WMIS to enhance the WRM process (Horne, 2015). Australia, for instance, has plans for the Australian Water Resources Information System (AWRIS) to become the backbone of all Bureau of Meteorology (BOM) water information products and services. This system is envisaged to be the base for developing national water data standards, sharing and licensing arrangements, dissemination of the water information standards, providing support for improvement of the coverage, accuracy and currency of the water data collected, makes such data accessible and many essential aspects of Australia's water resources management (Bureau of Meteorology, 2016).

Similarly, the United States Geological Survey (USGS) maintains the National Water Information System (NWIS) for the USA. It is a web-based tool that provides both historical and real-time streamflow data, groundwater level observations data, water quality data and a host of water-related information (Goodall, Horsburgh, Whiteaker, Maidment, & Zaslavsky, 2008). There are similar WMISs like the Integrated Water Resources Information System (IWRIS) in California's Department of Water Resources (DWR) which integrates data management functionalities such as consolidation of data sources from various water providers and other mapping functionalities (Borchardt et al., 2016). In Europe, many of the countries have such information systems which based on the European Union (EU) Water Framework Directive (WFD). The EU WFD has been influential in the monitoring and management of freshwater and habitats along the coast of Europe (Fölster, Johnson, Futter, & Wilander, 2014). One such information systems is WATERWARE. The system supports the integration of various databases, simulation models, GIS, and analytical tools which are combined into a system that supports the WFD. The water management literature showcases these implementations (Akhmouch, 2012; Gerlak et al., 2011; Wirkus et al., 2006; Zander & Kralisch, 2016).

Countries in Africa have also implemented WMISs extensively for water resources management. Examples of these systems are the Lake Victoria Decision Support Tool (LVDST) in Uganda, NileSim for planning of the Nile river basin from the Equatorial Lakes of East Africa the highlands of Ethiopia to the Egyptian delta, Water Resources Planning Model (WRPM) in South Africa, and host of others (Borchardt et al., 2016; McCartney, 2007). These systems have been implemented to enhance the planning, operations, and other vital aspects of WRM in various countries.

WMISs are implemented to support various functions in the entire WRM process and to aid in everyday water management decision-making within and across the water divide. Though there is a common theme of managing water resources sustainably and efficiently, each context is unique. The implementations are often aligned with the roles and responsibilities outlined in the nation's legislative and institutional frameworks (Horne, 2015).

Although the benefits of these systems have been acknowledged, there are concerns that they are underutilised and do not provide the desired outcomes. Further, there are concerns about the gap between the functionality of developed WMIS verses needs of relevant stakeholders and policymakers. This affects the success of the WMIS implementations (Giupponi & Sgobbi, 2013; Mysiak, Giupponi, & Rosato, 2005; Volk et al., 2009).

Researchers emphasise that successful WMIS implementation must give attention to the needs of stakeholders and do so within its local context (Giupponi, 2007; Volk et al., 2009). WMIS exist within a framework for water resources management and their successful implementation, and use must align with these frameworks. Doing so ensures that appropriate stakeholder and policymakers needs are also met. Globally and on the African continent, in particular, stakeholder participation is at the core of many of the WMIS implementation (McCartney, 2007).

However, there have been constraints to the success of WMIS implementations and use, mainly in Africa. These constraints have been of technical nature and are often due to limitations in financial, human and institutional or capacity (Georgakakos, 2006; Giupponi & Sgobbi, 2013; McCartney, 2007). There is also a lack of technical capacity to enhance the roles and functions for which the WMISs are employed for. The absence of a properly functioning WMISs poses a challenge to the success of the IWRM process.

The sections that follow discuss the support provided by WMIS for the stated aspects.

2.6.3 WMIS in Support of WRM Roles, Functions and Decision-Making

Water management functions and processes, and decision-making are relying on specialised and effective WMIS tools (Dent, 2010). The water management literature presents two broad purposes for which WMISs are utilised – Water Management for Decision-Making and Water Management Operations.

Table 2-1: Identified aspect and functions of water resources management

Aspect	Functions	References
Water Management Decision-Making	Production of reports, documents and knowledge products	Abdullaev & Rakhmatullaev (2014), Schreiner & Hassan (2010), Curry et al., DWA (2013)
	Decision on policy, legislation and regulation	Rivett et. al. (2013), Souza et al. (2009), DWA (2013), McDonnell (2008)
	Water management decision outcomes (water quality monitoring, water demand, infrastructure planning)	Rossouw et al., (2005), Rivett et al., (2013), Souza et al. (2009), Republic of South Africa (1998a), Grigg (2016), Zarli, Rezgui, Belziti & Duce (2014) , Horne (2015)
	Improve decision making quality	Giupponi & Sgobbi (2013), Miller et al. (2004), McDonnell (2008), Zarli et al. (2014) , Horne (2015)
	Supporting operations of the water management process	Souza et al., (2009), Abdullaev & Rakhmatullaev (2014), McDonnell (2008), Arsene et al., (2012), Grigg (2016)
	Enhancing	

	administrative duties	
Water Management Operations		DWA (2013), Rivett et al., (2013)
	Transparency and inclusivity of the water management process	DWA (2013), Abdullaev & Rakhmatullaev (2014)
	Promoting integrated water management	Abdullaev & Rakhmatullaev (2014), Schreiner & Hassan (2010), McDonnell (2008),
	Enhancing infrastructure planning	Badjana et al., (2015), Grigg (2016), Abdullaev & Rakhmatullaev (2014), Zeb et al., (2012), Rezgui, Belziti & Duce (2014)

Table 2-1 provides a summary of the functions identified from the water management literature relevant to the two aspects. The section the two aspects for which WMIS are utilised.

2.6.3.1 WMIS for Water Management Operations

WMISs are rapidly deployed to support water management, particularly in the developing world as part of alleviating the water resource challenges discussed earlier (Mongi et al., 2016). Water operations require systems that will provide the tools necessary to equip relevant stakeholders with the functionality to effectively manage the tasks. Activities including knowledge on water use for various purposes – agriculture, industrial, and household; tasks relating to the natural environment; social environment; and relevant external bodies (Abdullaev & Rakhmatullaev, 2014; Dent, 2010). Aspects such as water quality monitoring, water demand and use, and wastewater management are critical. For example, the quality of water is related to health and water managers must ensure water quality standards in the shortest period at different stages – raw, treatment and distribution – before it ends up at the consumers'. Bracht (1995) asserts that information systems for water resources management should align directly with the tasks and operations that arise.

Data acquisition and storage, data retrieval, data management, information generation and an uninterrupted network that allows for the sharing of the data between relevant stakeholders, are critical to these daily operations and WMISs provide these capabilities for such purposes (Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Bracht, 1995; Eludoyin, 2007; Rossouw et al., 2005). The WMIS for the tasks and purposes earlier described are specialised and often combine characteristics and functionalities to address the task at hand. In the South African context, a range of WMIS has been implemented at different levels of water management. Souza et al. (2009) elaborated on the electronic Water Quality Management System (eWQMS), which is an open source software based system, implemented and maintained by all WSAs in South Africa to improve management of water quality and its associated services. Not only does the system aid water management at provincial and national levels, but it also it provides access to the public as well. The data outcomes have formed part of the foundation for South Africa's Drinking Water Quality Regulation System (DWQRS), better known as the Blue Drop System (BDS) as well as the monitoring and regulation of the performance of WSAs.

Jacobs and Fair (2012) describe a system that integrates existing systems to obtain information on water consumption for users in various municipalities within South Africa. The system, Sewsan and Wadiso Interface to Treasury (SWIFT™), consolidates information from some treasury systems, another system Wadiso™ and Sewsan™ (GLS Consulting, 2017). The analysis of the data is done from an information management perspective. Another system, Master Plan, allows water manager and stakeholders to plan the water infrastructure. This supports the larger

Water Demand Management (WDM) strategies in place for water resources management in South Africa (Fair & Compion, 2008).

Balfour, Badenhorst and Trollip (2011) undertook an extensive study on laboratory systems in South Africa. The Water Services Act (No. 108 of 1997) provided strict standards for the quality of water, and their study showed the important role these systems play in aiding the achievement of the water quality goal. The larger water bodies, potable drinking water and effluent, must be thoroughly assessed and laboratory information management systems support the functions. This does not end there, as reporting standards for the data output are also essential. These systems ensure that the relevant standards, SANS 241, ISO 17025:2005, and all other standards are duly met.

Clifford et al. (2014) discuss the WATERNOMICS approach to interactive water services. The focus was on using ICT as an enabler in the management of water resources by increasing end-user water conservation awareness and affect behavioural changes. Such systems seek to bring all the water information to various stakeholders – municipalities, citizenry and all others who have a stake in water resources management.

These systems described, provide ample evidence of the different implementations for operations at the different levels of water resources management. All these different systems reflect the role IS plays as a tool in coordinating process, enhancing information sharing among various stakeholders, and other functions and responsibilities for efficient water resources management.

2.6.3.2 WMIS for Water Management Decision-Making

It has already been discussed that managing water requires interdisciplinary approaches due to its complexity. Within the water management organisations, decision-making is an everyday occurrence in their operations and management, and WMISs are essential in this decision-making process. Many of the specialised systems are decision-making tools. As an example, laboratory information systems provide the needed data for water managers to make decisions on the state of the water quality on a regular basis.

Specialized WMISs in the form of Decision Support Systems (DSS)) have been developed and implemented to enhance the decision-making processes and to navigate the complexities in water resources management (K. Zhang, Zargar, Achari, Islam, & Sadiq, 2014). What is a DSS, and is not, is discussed extensively in the literature but at its core is the aim of making effective decisions (K. Zhang et al., 2014). DSS be it model, analytical tools, and systems, are designed to support water resources management challenges (Balsam, 2016). Many DSS have been developed for different purposes and at varying levels of water resources management. Projects like WATERNOMICS and WISDOM attest to the importance of WMIS to water management operations and decision-making at various levels of WRM (Clifford et al., 2014; Kouroupetroglou et al., 2015; Zarli et al., 2014).

Mysiak et al. (2005) developed a DSS, MULINO DSS(*m*DSS), that integrates environmental (hydrological) models with multi-criteria evaluation procedures for water resource management. The system was based on the DPSIR (driving force-pressure-state-impact-state-response) framework and consisted of three prototypes. They state that the *m*DSS tool has the potential to contribute to the water framework directive mainly when used by the relevant stakeholders.

Aher et al. (2014) applied a web-based Watershed Management Information System (WATMIS) – a DSS that incorporates Geographical Information System (GIS), Remote Sensing (RS), Global Positioning System (GPS), hydrological modelling and soft computing tools – over a watershed that was located at Pimpalgaon Ujjaini

(Ahmednagar District), India. An integrated object-oriented relational approach database was employed for various modules to increase its robustness and applicability to land and WRM. They conclude that such an application is useful for the different water resource managers and stakeholders in decision-making on watersheds.

The Swift system introduced earlier provides modules that summarily enhance the decision-making process water demand and consumption, unaccounted for water, provided an extensive statistical report, performs financial analysis, visual queries via spatial information and host of others all used for enhancing the decision-making process (EOH, 2015b).

Kelly (2015) developed a CAPER (Catchment Planning and Estuary Response) DSS to support water quality improvement planning. The system integrated information to come up with the Water Quality Improvement Plan (WQIP). The DSS was applied in the Tamar river estuary in North Eastern Tasmania to develop the Tasmania Estuary and Esk Rivers (TEER) WQIP. The result showed that the DSS supported the development of the WQIP, a process that engages multiple stakeholders. It allowed for a range of management options to be built from various base models.

Mongi and Meinhardt (2016) in a study of ICTs for water resources management – at the basin level in Southern Africa – found that ICT solutions were mainly for decision support. This is not at all surprising as water is known to be a shared responsibility between multi-stakeholders at different levels – local, regional and national.

There are many more studies that have been conducted globally on DSS for water resources management in the literature (Gourbesville, 2008; Gourbesville, Du, Zavattero, & Ma, 2016; Junier & Mostert, 2014; Labadie, 2006; Magiera, Jach, & Kurcius, 2017; Shim, Warkentin, Courtney, & Power, 2002). The academic literature on DSS and water resources management will continue to grow as all stakeholders involved continue to find solutions to the complex water management problem.

In summary, the literature shows enormous support for the use of WMIS for water management decision-making. These WMISs have provided water managers and stakeholders the ability to understand different perspectives of water management – water quality, water demand and consumption, policy, and other aspects – at the various management levels using the WMO information (Anzaldi et al., 2014). Currently, how the WMIS support for the aforementioned areas of water management and how the vital elements of the systems affect the successful outcomes of the water management institutions are not known. Junier and Mostert (2014) argue that technically, three aspects of DSS affect its success: the usefulness (that is how it fits the purpose for which it is used and ease of use), the knowledge base, and availability of data for the process. However, there is no study in the water management or IS literature that has studied how these fit into a model of WMIS success. In summary, WMIS use for decision-making is essential for the overall water management process as previously discussed. Thus, the analysis suggests that WMIS use for decision-making also affects overall success outcome.

2.7 IMPLEMENTATION AND SUCCESS OF WMIS FOR WRM OPERATIONS AND DECISION-MAKING

The discussion on WMIS implementations at the different levels of water management for operational and decision-making above has presented some factors that affect the success of WMIS implementations. Some of the factors include aspects of the WMIS that aid the roles and responsibilities of the water management institutions, data and information requirements, and standards (top hierarchy, external bodies and other relevant stakeholders) that must be met by the water management organisations. (Abdullaev & Rakhmatullaev, 2014; Giupponi & Sgobbi, 2013; Miller et al., 2004; Rossouw et al., 2005; Souza et al., 2009).

Souza et al. (2009) attribute the success of an electronic water quality management system developed and implemented in South African WSAs to some factors. Broadly the factors bordered on the system – ease of use, reliability, security, data output quality for the water organisation and stakeholders; stakeholder and other external environmental requirements – satisfying WSA and DWA requirements and regulations; improving the water management process; and affect behaviour on water quality.

Dent (2010) also provide critical operational requirements of WMIS based on socio-scientific necessities. Again, the aspects highlighted have to do with interoperability standards of data and information. There are multiple stakeholders involved at different levels of water management, and it is essential to maintain data interoperability standards. A further attribute is the accessibility of the data and information. The author posits that the basis of the democratic process of water allocation and delivery is the equitable, convenient and unimpeded access to data and information. Concerns about data and information mainly are continually discussed due to its importance and place in water resources management. The argument is that water resources management relies heavily on data and information and it must be managed appropriately. Curry et al. (2014) claim that effective and efficient water management requires a holistic approach that requires good information management practices – integration of heterogeneous data, and the real-time processing of data. No matter the level at which systems are implemented, aspects such as the data sharing, data ownership, data standards, aspects dealing with data accuracy and currency, data needs, provision and many others have to be taken into careful consideration (Curry et al., 2014; McDonnell, 2008). Chao et al. (2015) studied data quality assessment in hydrological information systems and asserted that data inputted into this type of DSS might be untimely, incomplete or illogical due to technical system challenges, instrument failures or purely human errors. They suggest that it is essential to assess, monitor and to a more considerable extent control the quality of the data through the data supply chain. In the case of the mDSS project, one of the conclusions made by Mysiak (2005) was that the end-users involved in the implementation are essential to the success of the system. Another critical factor was the having multiple decision to give decision-makers options. Mongi and Meinhardt (2016) affirm that user-centred design plays a crucial role in supporting implementation, its use for water-related activities and also meeting water sector goals for sustainability. Another study by Rossouw et al. (2005) recommended that user participation in the WMIS development process is needed.

To achieve the full potential and set objectives for the implementation of any WMIS, leadership and culture of the water management organisation, and user behaviour is also considered important (EOH, 2015a). Rossouw et al. (2005) suggested that support from water managers informs the success of the WMIS and in their case, information requirements were well articulated.

What has been argued out in this section is that various WMIS exist for various water management functions and operations and decision-making. These discussions show that the literature provides evidence of implementations, lessons learnt in some cases, factors that account for success in other cases, challenges and suggestions. These considerations either have to do with the system or technology, water management organisation – leadership, structure and environment, end-users and the expected outcomes of WMIS thereof. The ability of water management organisations and relevant stakeholders to effectively implement and benefit from WMIS is vital to its success.

2.8 SUMMARY

Water resources management involves many stakeholders and actors. It was argued that due to the many aspects and multi-stakeholder nature of water resource management, a holistic and transdisciplinary approach is required. IWRM, one of such known approaches, was extensively discussed. Since IWRM is understood in its practicality, the South African case was used as a basis and discussed. The various levels – national, provincial, and local – of management, actors and stakeholders (including external institutions and bodies) at the different levels, the associated roles and responsibilities, and the information flow are presented. I show how the information flow and hierarchy of management affects the management of the information. ICTs, one of the crucial actors in the management process – information management and sharing, water management roles and responsibilities, decision-making and others – is introduced. Specialized ICTs for water resources management, known as WMIS, are thoroughly discussed. Two primary uses of WMIS in the everyday management of water, operations and decision-making, are further discussed. I elaborate of these systems and provide examples from literature of some of the systems being used in aiding operations and decision-making. The success of the various WMISs in assisting the operations and decision-making thereof is dependent on some factors. These factors are associated with the WMIS, roles and responsibilities within the WM organisations, information requirement, and stakeholder requirements, of which I provide support from water management literature.

I proceed to discuss WMIS success evaluation in detail and introduce models for IS success evaluation. The aim here is to provide the background for the WMIS success model to be developed in this research.

3 THEORETICAL BACKGROUND OF THE MODEL

3.1 INTRODUCTION

In this section, the theoretical background of the developed model for this research is presented. As an information system, WMIS avails itself to theories and concepts on IS success in general. These theories and concepts will provide an understanding of the WMIS success. Of interest to this study are the DeLone and McLean IS success model (DeLone & McLean, 1992, 2003) and the HOT-Fit Framework (Yusof, Kuljis, Papazafeiropoulou, & Stergioulas, 2008). The two frameworks serve as the basis for the various factors and dimensions of WMIS success in water resources management to be developed. Based on the discussion of Section 2.7, theories on two types of leadership – transactional and transformational – are introduced, and then I discuss the structure and environment of WMIS success in water resources management.

3.2 SUCCESS AND FAILURE OF WMIS

Despite the widespread use of WMIS for the operations and decision-making processes in water resources management, not much attention has been given to their success. However, the calls and the need to assess and evaluate the success of systems have been presented in water resources management (Abdullaev & Rakhmatullaev, 2014; Balsam, 2016; Giupponi & Sgobbi, 2013; Mongi et al., 2016). Various WMISs have been employed for water resources management within the developing world context with varying success levels (Abdullaev & Rakhmatullaev, 2014; Eludoyin, 2007; Giupponi & Sgobbi, 2013; Harris et al., 2001; Jacobs, 2008). The many studies on WMIS use are limited to severally discussing the various types of WMIS implemented or deployed for an aspect of water management or a particular purpose, data and information requirements for the WMIS, technical requirements, institutional and stakeholder requirements, and others (Abdullaev & Rakhmatullaev, 2014; Eludoyin, 2007; Giupponi & Sgobbi, 2013; Gourbesville, 2008, 2011; Gourbesville et al., 2016; Rivett, 2012; Schaub-Jones et al., 2014; Souza et al., 2009).

There is a gap in knowledge on assessment of WMIS although the literature presents evidence of the factors and criteria related to the uses above of WMIS, institutional and stakeholder requirements and others. The success or failure thereof of a WMIS is thus determined by factors which are both institutional and technical (Abdullaev & Rakhmatullaev, 2014; Eludoyin, 2007; Mongi et al., 2016). Junier and Mostert (2014) recommended three essential component of WMIS success: usefulness of the tool, specifically the WMIS's fit for its intended purpose and the ease of use; how it replicates reality (i.e. knowledge base); and data availability for processing. In this regard, Souza et al. (2009) acknowledged that the importance of the usefulness to the success of WMIS. The authors state that the fit of the system to the needs of WSAs in the case of the water quality monitoring system in places affected the success of the overall system. Ensuring that a WMIS is useful for the intended purpose – tasks, processes and needs – of users and stakeholders alike can prevent failure. It is, therefore, essential to consider a close and constant collaboration between users and stakeholders in the sector.

Many studies have also elaborated on other technical aspects that influence the success of WMIS (Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Eludoyin, 2007; Souza et al., 2009; Zander & Kralisch, 2016). Abdullaev and Rakhmatullaev (2014) concentrated on the data management aspects of water resources management. The importance of such data and information at the various water management hierarchy has already discussed. The interface design and functionality, access to the data and information, and interpretation of such data are all considered fundamental to its success. Other authors acknowledge the importance of the data aspect of WMIS to its overall success. In this regard reliability, accuracy, consistency, timeliness, among other relevant aspects of data are discussed in the literature (Chao et al., 2015; Delden, Seppelt, White, & Jakeman, 2011; Giupponi & Sgobbi, 2013; Junier & Mostert, 2014; Mongi et al., 2016; Souza et al., 2009). The customizability, user-friendliness and other technical aspects of the systems are also considered critical to the success of WMIS and discussed extensively in the water resources management literature(Delden et al., 2011; Eludoyin, 2007; Giupponi & Sgobbi, 2013; Gourbesville, 2008; Miller et al., 2004; Zander & Kralisch, 2016).

The success of WMIS is also attributed to other non-technical system aspects. These are mainly stakeholder, financial, organisational, and socially oriented (Abdullaev & Mollinga, 2010; Abdullaev & Rakhmatullaev, 2014; Volk et al., 2009). Stakeholder involvement from implementation through to the adoption of WMIS is important to its use for the desired functions and overall success (Junier & Mostert, 2014; Mysiak et al., 2005). These stakeholders as discussed in the institutional structures can be both external and internal to the water management organisations. Their functions and information need to play a critical role in its success. The users of the WMIS who can be considered as part of internal stakeholders can provide tremendous insight into the areas such as the aesthetics, local or contextual support measures, end-user needs (Junier & Mostert, 2014; Volk et al., 2009). The study by Souza et al. (2009) in the case of the eWQMS for water quality monitoring in South Africa highlighted the importance of incorporating stakeholder perspectives and requirements. The authors acknowledge the alignment of the eWQMS to stakeholder requirements is key to its success. A strength of this study will be the inclusion of stakeholder and other standards such as the water quality requirement by DWS.

Giupponi and Sgobbi (2013) also highlighted the importance of stakeholders through the learning experiences of a DSS implementation in Africa. IWRM involves multi-stakeholder participation and thus their involvement – viz their experiences, functions, compliance and needs – is critical the success of these systems. Several other authors have discussed stakeholder involvement in the success of WMISs (Delden et al., 2011; Eludoyin, 2007; Gourbesville, 2008, 2011; Mysiak et al., 2005; Schaub-Jones et al., 2014). The devolution of the IWRM in the SA context discussed earlier provides this study with the various roles and functions needed to understand WMIS success. The roles and functionalities have requirements and standards regarding outcomes and technical and non-technical requirements.

The discussion above provides evidence that WMISs are implemented with the aim of enhancing functions, processes and decision-making at all levels of water management. The success of these WMISs depend on both technical (system) and non-technical (non-system) factors related to the system, various stakeholders and institutions alike within the water management organisations.

Table 3-1: Some identified factors that contribute to WMIS success

Technical	**Non-technical**
Data (availability, accuracy, consistency, quality, reliability)	Stakeholder involvement
Ease of Use	Meeting water management organisation functions and needs
Reliability	Financial challenges
Security	Stakeholder and organisational compliance
Customizability	Supporting regulatory functions
User-friendliness	

Usefulness	Perceived benefits
Flexibility	User satisfaction
Skills and expertise	Importance of WMIS output
Interoperability	Environment
	Water management organisation functions and needs
	Added value of WMIS to policy

Table 3-1 shows some of the common factors attributed to WMIS success from the water management literature. These are common findings from the many WMIS implemented at the various level of water resources management.

The literature suggests a consensus on the lack of evaluation of WMIS success in the different contexts (Abdullaev & Rakhmatullaev, 2014; Mongi et al., 2016; Mysiak et al., 2005). Considering the many studies on WMIS above and the discussion on factors which contribute to their success, this research fills the gap by developing a model for WMIS success evaluation.

In the next section, I discuss WMIS success evaluation and more importantly what challenges are encountered in the literature.

3.3 WMIS SUCCESS EVALUATION

Evidence from the water management literature suggests that WMIS evaluation has not been extensively researched (Abdullaev & Rakhmatullaev, 2014; Mongi et al., 2016; Mysiak et al., 2005). This point is buttressed by Mongi and Meinhardt (2016) in their research on integrated ICTs for water basin management in Southern Africa. They posit that the identified relevance criteria in their study will not only help in designing a framework to guide output, but it will be necessary for outcomes and evaluation of ICT in water resources management. The evidence of factors, criteria, and conditions – concerning the systems, water management organisations, stakeholders, and others – that influence the success of WMIS as seen previously has extensively been presented. The gap to be filled is how these can be used to evaluation WMIS success. To fully comprehend WMIS success evaluation, there is the need to understand the challenges of WMIS success evaluation, and some approaches that have been taken to evaluate such success.

The lack of studies on the subject matter has been attributed to some reasons in the water management literature (Mongi et al., 2016; Mysiak et al., 2005). Mysiak et al. (2005) contend strongly that the lack of studies can be attributed to a significant point of concern: the difficulty of understanding what WMIS success evaluation and how to develop such an assessment model or framework. Despite the ambiguity, the contexts of the different implementations provide lessons and factors which many authors have already presented. Understanding this challenge should guide the WMIS success model to be developed in this study.

The success of WMIS in the water management literature is often described in terms of water management organisation functions and needs, stakeholder requirements, environmental conditions, the organisation set up of the WMO and the other technical and non-technical terms outlined in Table 3-1 (Delden et al., 2011; Giupponi & Sgobbi, 2013; Mongi et al., 2016; Volk et al., 2009; Zander & Kralisch, 2016). The WMIS should align with the functions and needs set out by of the water management organisations (Gourbesville, 2011; Junier & Mostert, 2014; Volk et al., 2009). In this case, the functions outlined in the IWRM process must be enhanced when the WMIS is implemented. Not understanding and aligning the WMIS to the functions and needs of the WMO is likely to affect the successful outcome of the implemented system (Mongi et al., 2016).

Further, stakeholder requirements and participation are discussed extensively as part of WMIS success (Delden et al., 2011; Junier & Mostert, 2014; Volk et al., 2009). As already discussed, the nature of water resource management and particularly the approach of IWRM is a multi-stakeholder undertaking and WMIS are the centre of it all (Gourbesville, 2011; Volk et al., 2009). The sharing of information and coordination of activities between these means stakeholder involvement and participation in how the WMIS meet requirements that the management of the resource is considered critical (Delden et al., 2011; Junier & Mostert, 2014). The environment or context and organisation setup also form part of how WMIS success is evaluated (Giupponi & Sgobbi, 2013; Junier & Mostert, 2014; Mongi et al., 2016; Souza et al., 2009). Predominantly, some previous WMIS evaluations have been based on only user perception on usefulness, user satisfaction, subjective impressions, cognitive styles, aspects as training and skill to more technical system aspects already identified (Lu, Yu, & Lu, 2001; Mysiak et al., 2005).

Given the understanding of WMIS success evaluation just presented, an evaluation of WMIS must be done based on factors that are both technical and non-technical. In essence, this study will fill the knowledge gap by developing a model that addresses this limitation by considering these characteristics as mentioned above of WMIS success as discussed in the water management literature.

I proceed to discuss two IS success evaluations models, the HOT-Fit Framework and DeLone and McLean IS Success model, which will serve as the basis for the WMIS model to be developed.

3.4 IS SUCCESS EVALUATION MODELS

IS success evaluation is an established area of research in IS and there is an abundance of literature on the subject matter (DeLone & McLean, 1992, 2003; Hellstén & Markova, 2006; Petter, DeLone, & McLean, 2008; Seddon, 1997; Skog, 2009; Yusof, Papazafeiropoulou, Paul, & Stergioulas, 2008). In evaluating any IS, the criteria for evaluation should be based on the strategies, goal and objectives of the organisation under study. Economic, operational and strategic approaches are popular for IS project justification evaluation. IS implementation evaluations are often difficult due to the inability of stakeholders to have a clear implication during the implementation. However, the lifecycle could be considered. The commonly used implementation criteria are categorised as financial, non-financial, tangibles and non-tangibles (Gunasekaran, 2006).

Effective IS success evaluation is considered to have both practical and research significance. It provides both researchers and practitioners with an understanding of the value – management, investment, and purpose – of IS (DeLone & McLean, 2003; Hellstén & Markova, 2006). The concept of IS evaluation is considered multidimensional and occurs at different levels and involve multiple stakeholders. Therefore, the concept of IS success will take on varying meanings in different context. This means different studies and systems cannot be compared (Hellstén & Markova, 2006). Within the IS literature, a number of models and frameworks of IS success evaluation have been developed and utilised for varying purposes. Often in the IS literature, researchers have provided empirical evidence and validation to some of the models or extended a selected model in various contexts (Gable, Sedera, & Chan, 2008; Palmius, 2007; Petter et al., 2008; Seddon, 1997; Visser, Van Biljon, & Herselman, 2013).

An overview of the conventional models or base models from the IS success evaluation literature is presented in the table below.

Table 3-2: Overview of some IS Success Models and underlying theories – Adapted from (Visser et al., 2013)

Model Description	Based On	Developer(s)
Expanded Mathematical Theory of Communications	Mathematical Theory of Communication(Shannon & Weaver, 1949)	(Mason, 1978)
Computer User Satisfaction (CUS)	Behavioural Theory of the Firm (Cyert & March, 1963)	(Bailey & Pearson, 1983)
End-User Computing Satisfaction (EUCS)		(Doll & Torkzadeh, 1988)
Integration of User Satisfaction (US) and TAM	Beliefs and attitudes about the system, and Beliefs and attitudes about using the system	(Wixom & Todd, 2005)
Technology Acceptance Model (TAM)	Theory of Reasoned Action, Theory of Planned Behaviour (Ajzen & Fishbein, 1975)	(F. Davis, Bagozzi, & Warshaw, 1989)
Technology Acceptance Model 2 (TAM2)		(Venkatesh & Davis, 2000)
Unified Theory of Acceptance and Use of Technology (UTAT)		(Venkatesh, Morris, Davis, & Davis, 2003)
Technology Acceptance Model 3 (TAM 3)		(Venkatesh & Bala, 2008)
Task Technology Fit Model (TTF)		(Goodhue & Thompson, 1995)
Combined TAM/TTF Model		(Dishaw, Strong, Bandy, Dishaw, & Strong, 2002)
DeLone and McLean (D & M) IS Success Model	Extended Mathematical Theory of Communications (Mason, 1978)	(DeLone & McLean, 1992)
Extended D&M IS Success Model + TAM		(Seddon & Kiew, 1996)
Respecified D&M Model		(Seddon, 1997)
Updated DeLone an McLean IS Success Model		(DeLone & McLean, 2003)
HOT-Fit Framework	D&M IS Success Model TTF	(Yusof, 2011; Yusof, Paul, & Stergioulas, 2006)

The overview presented in the table above points to a predominant core set of theories and models from which most are derived. In light of the earlier discussion on WMIS success evaluation in Section 3.3, two IS success models are of interest to this study; HOT-Fit Framework and DeLone and McLean IS success model (DeLone & McLean, 1992, 2003; Yusof, Kuljis, et al., 2008). While the DeLone and McLean (1992, 2003) model have been studied extensively in the IS field to understand and evaluate of IS success for a wide range of information systems (Rai, Lang, & Welker, 2002; Ssemaluulu, 2012), the HOT-Fit framework developed by Yusof et al. (2008) has been employed for HIS success evaluation.

Whereas the D&M IS model and HOT-fit framework provide this study with the needed technical and user-centric parameters required, the HOT-fit framework alone brings the necessary organisational aspect. The devolution of the IWRM through the various roles and functions within the WRM organisational setup means the HOT-fit framework aligns with this study. These two models are crucial to this study. Further, these two models avail themselves for appropriate and rigorous quantitative analysis – the primary approach to this study – to be performed.

In the sections that follow, I discuss these two models which form the bases for the WMIS success model to be developed for this study.

3.4.1 DeLone and McLean IS Success Model

The DeLone and McLean IS success model has been studied extensively in the IS literature. Based on the exemplary research by Shannon and Weaver (1949) on communication theory, Mason's 1978 work on measuring information which also draws on communication theory, and extensive empirical evidence from MIS studies, DeLone and McLean (1992) proposed their first IS success model.

The model consisted of six dimensions: System Quality, Information Quality, Use, User Satisfaction, Individual Impact and Organisational Impact (See Figure 3-1).

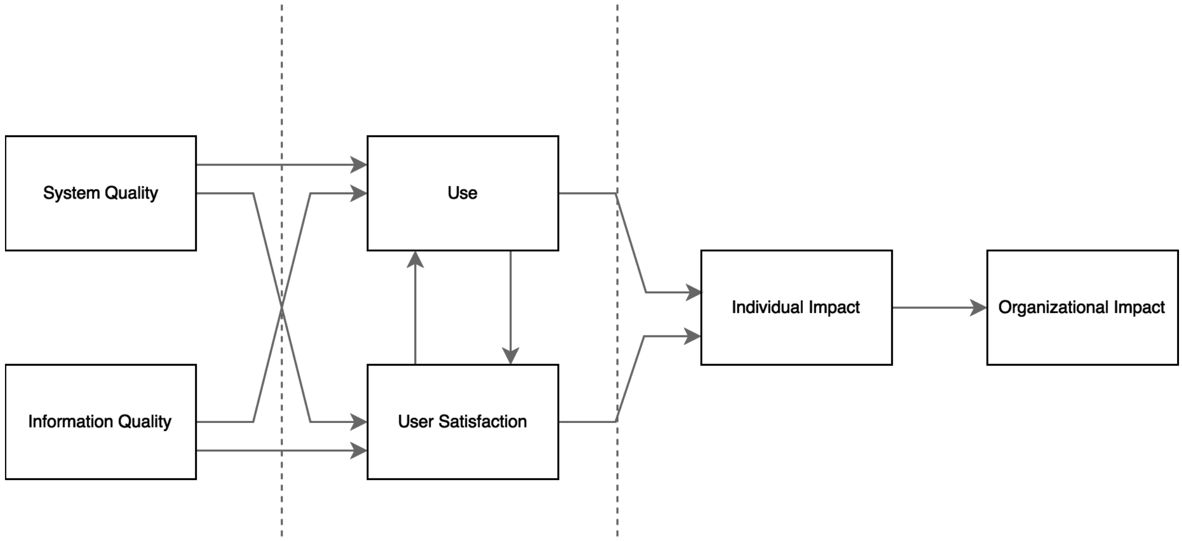

Figure 3-1: DeLone and McLean IS Success Model (DeLone & McLean, 1992)

In their initial model, DeLone and McLean (1992) asserted that *System Quality* and *Information Quality* affected *Use* and *User Satisfaction* individually and together. Further, the amount of *Use* negatively or positively affected *User Satisfaction. Use* and *User Satisfaction* affected *Individual Impact* which then influenced *Organisational Impact.*

DeLone and McLean (2003) updated the earlier model they developed after many studies implemented (Rai et al., 2002; Seddon & Kiew, 1996) the more previous model, and in some cases extended (Seddon, 1997) and crticised it (Rai et al., 2002). As can be seen in Figure 3-2, the updated model included a new dimension *Service Quality* – the overall support provided to the users of the system by the appropriate support staff or personnel; *Net Benefits* – important success measures that capture both positive and negative impacts on the individual or organisation. It should be noted here that, the new model merged the *Individual* and *Organisational Impact* from the earlier model to form *Net Benefits*. The dimensions of IS success measure remained at six.

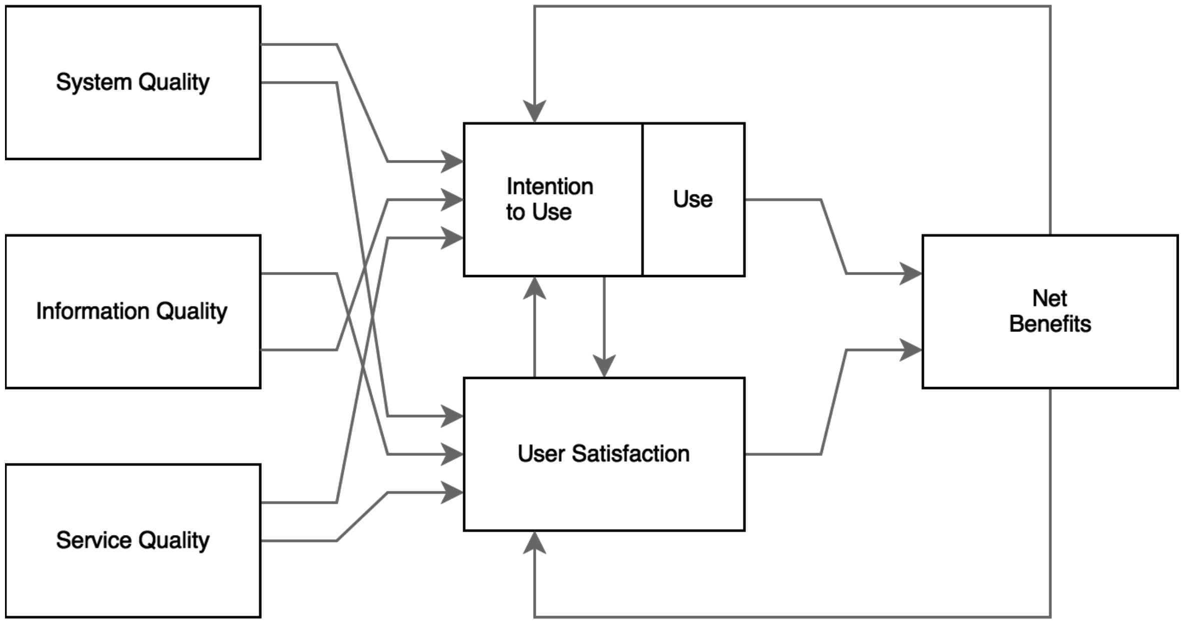

Figure 3-2: Updated DeLone and McLean IS Success Model(DeLone & McLean, 2003)

They emphasise that *Net Benefits* are the most important success measures. However, they cannot be examined and adequately understood without the *System Quality* and *Information Quality* measures.

The IS literature presents several implementations, validations and extensions of the initial and the updated models. However, the updated model is the often referred to in contemporary studies. Iivari (2005) validated the DeLone and McLean IS success model through a study of a municipal financial and accounting system in Oulu City Council, Finland. Wang and Liao (2006) also validated the DeLone and McLean model by assessing e-Government systems success in Taiwan.

There have been many studies that validated the model too (Alshibly, 2014; S.-K. Lee & Yu, 2012; Petter et al., 2008; Petter & McLean, 2009). Other studies have also conceptualized and extended the model – Knowledge Management Systems (KMS) (Halawi, McCarthy, & Aronson, 2008; Kulkarni, Ravindran, & Freeze, 2006; Wu & Wang, 2006); Health Information Systems (HIS) (Yusof, Papazafeiropoulou, et al., 2008) and others (H.-J. Chen, 2010; Roky & Al Meriouh, 2015; Seddon, 1997)

The discussion has shown the different studies for which the DeLone and McLean IS success model has been adapted to. Indeed it has formed the basis for many of the IS success studies and continues to do so. One of such success models for which the DeLone and McLean IS success models serves as basis and is relevant to this study is the HOT-Fit framework. In the next section, I discuss this framework and justify its selection as the basis for the WMIS Success Model.

3.4.2 HOT-Fit Framework

The HOT-Fit framework was proposed for the evaluation of Health Information Systems (HIS) by Yusof et al. (2008). This framework has origins in the IT-Organisation fit model, and the DeLone and McLean IS success model previously discussed. The IT-Organisational fit model consists of internal and external elements of fit. The internal fit is attained through a dynamic equilibrium of components within the organisation including the organisational structure, management processes, strategy and the roles and skills. The external fit is attained by formulating the organisational strategy based on the environmental factors. These should subsequently affect the management processes as they serve as enablers for IT implementation. The IT-Fit model further indicates that, aside the internal and external fit, organisational vision, organisational strategy and robust IT infrastructure should be pre-requisite for realising the benefits of the IT implemented (Yusof, Kuljis, et al., 2008).

Yusof et al. (2008) then proposed the HOT-Fit framework based on these two models that built on the strengths of the DeLone an McLean IS model and a non-existent organisational dimension. The framework consists of three factors – Human, Organisation and Technology. The foundations of this framework are the DeLone and McLean IS Success Model (2003) and IT-Organisation Fit Model as foundation for the framework. The latter brings the concept of fit to between the various dimensions. The model introduced a new factor and new relationships. The first extension the base models was the addition of organisational factors with two dimensions – *Structure* and *Environment* and proceeded with evaluation measures as guidance. They also a fit between the factors as seen in Figure 3-3 and new two-way relationships: *Information Quality – System Use*, *Information Quality – User Satisfaction*, *Organisational Structure – Environment*, *Organisational Structure – Net Benefits*, *Organisational Environment – Net Benefits* in the healthcare context.

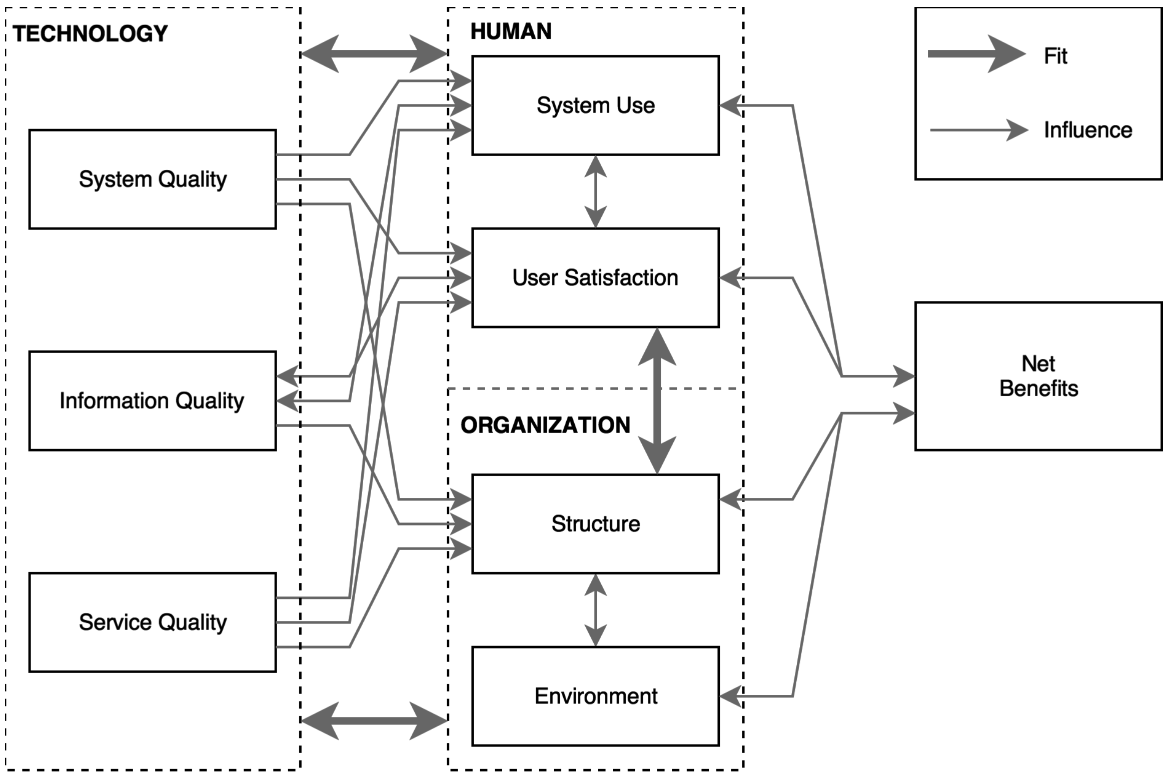

Figure 3-3: HOT-Fit Framework (Yusof, Papazafeiropoulou, et al., 2008)

Yusof (2011) refined the HOT-Fit framework to include a new dimension of human factor; *System Development*. The System Development dimension relates to processes in the system development life cycle. Some of these include clarity of the systems purpose, feasibility study, planning, design, system selection, project management, momentum, user involvement and others.

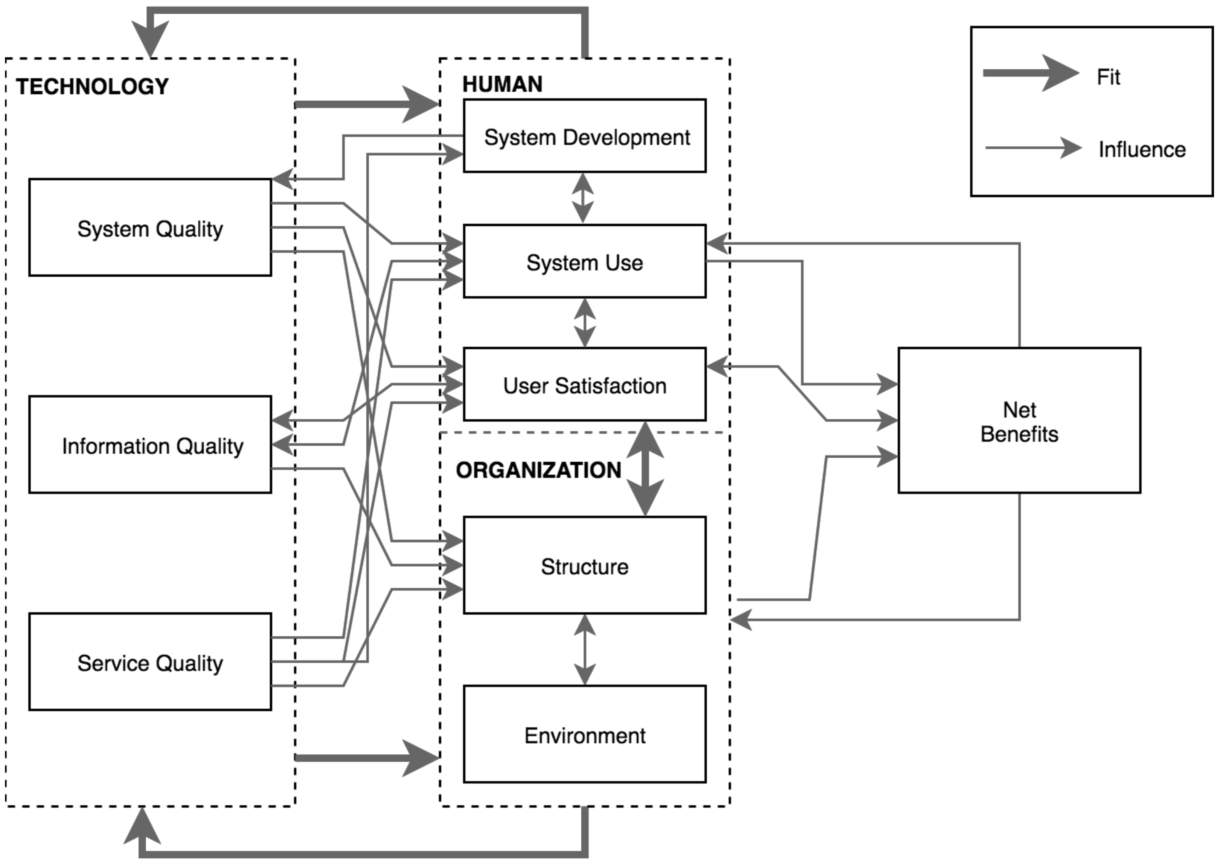

Figure 3-4: Refined HOT-Fit Framework (Yusof, 2011)

The author states that the three evaluation factors can occur through the entire system development cycle which is specified in the System Development dimension.

The concept of fit in the context of HOT-Fit they described as the ability of stakeholders and the various clinical practices to align. Erlirianto (2015) validated the model by evaluating an Electronic Medical Record (EMR) System in a type-C hospital in the East Java Region of Indonesia. The second study was the evaluation of an e-Government system (Project Monitoring System) effectiveness in Malaysia by Yusof and Yusuff (2013).

The original HOT-Fit framework provides dimensions relevant to the proposed WMIS success model. In this study, the WMISs presented have been in existence for the past two decades and hence the refined model did not align with the proposed model. This study thus opts aspects of the original HOT-Fit framework as the base model for this study. Further, leadership is under-represented for its adaption in water resources management. Hence, this study elevates it a dimension. IWRM has leadership as a critical part of the process which the framework does not address as a substantial part; instead, it sees leadership as a variable of the structure. Water management leadership is considered one of the most critical enabling factors for effective water utility management (Funke et al., 2007; Grigg, 2011; Hooper, 2003; Lincklaen et al., 2013; Moore, 2013; Taylor, 2016). The absence of leadership as a dimension is a limitation to the envisaged WMIS success model. Leadership is needed for effective management, guidance and participatory processes at all stages of IWRM (Funke et al., 2007; Hering & Ingold, 2012). Hence, this study modifying the framework by introducing the leadership dimension and its measures from the water management literature. I follow with a discussion of two leadership styles from leadership theory and its effect on water resources management and WMIS in general.

3.5 LEADERSHIP AND LEADERSHIP STYLES

The concept of leadership has evolved from being about characteristics of an individual to encompass collective processes, shared goals, behaviours and efforts in a complex social environment (Avolio, Walumbwa, & Weber, 2009; Yukl, 2010).

The effect of two forms of leadership – *Transactional* and *Transformational* – are commonly discussed in the IS literature (Avolio, Bass, & Jung, 1999; Burns, 1978). The section that follows discusses these two leadership styles and provide evidence studies in the IS and water resources management literature.

3.5.1 Transformational and Transactional Leadership in Water Resources Management

The contrast between transformational leadership and transactional leadership was first introduced by Burns (1978). Transformational leadership is considered one of the most important organisational behaviour theories. Transformational leaders cause a change in attitudes and assumptions of their followers' through motivation of their behaviour (Wright & Pandey, 2010). Wright and Pandey (2010) assert that these type of leaders motive individual efforts by transforming their followers through awareness. The raising of awareness on the importance of the outcomes of the organisation activates the higher order needs of these individuals thereby inculcating a sense of working for the larger good of the organisation instead of themselves. They provide come conditions that transformational leaders must adhere to. They must motivate followers in an inspirational manner, be an idealised influence source and intellectually stimulate the followers.

Leaders are known to conduct themselves in ways that have a transformational effect on the values and world-views of the people they lead and also through the provision of vision and strategies transform behaviours (Kaushal, 2011). Transformational leaders focus on intangible qualities – shared values, vision and relationship building (S. Chen, 2006).

Transactional leadership is characterised by contingent reward and management-by-exception (Dussault, Frenette, & Fernet, 2013; Schepers, Wetzels, & Ruyter, 2005). For the contingent reward, followers are rewarded when they do what is expected of them and accomplish a specific task, meet goals, and organisational objectives agreed on. Management-by-exception is when leaders do not provide instructions or directions. However, the leader reacts to the mistakes made by the followers or certain performance standards are not met and proceeds with actions. They only intervene when problems arise and fail to provide instructions or directions once the present ways of working are effective (Dussault et al., 2013; Schepers et al., 2005). They do no promote the long-term goals of the organisation.

Wright and Pandey (2010) further state that though it was expected transformational leadership would be better than transactional or reward-based leadership, empirical findings from the literature suggests that there is the need for leaders augment transactional behaviours with those of transformational behaviours. A similar suggestion has been brought forward by several authors in the leadership literature (Avolio et al., 1999; Bass & Avolio, 1996).

Taylor (2016) studied the significance of transactional and transformational leadership in the management of water utilities in Australia and found leadership as the most crucial enabling factor in the effective management of water utilities. To understand what leadership style suited the water utilities, the study drew on Bass's range of leadership theory – transformational, transactional and a mix of the two. The study concludes based on empirical evidence that a mix of the two, transactional and transformational leadership, was the most effective in managing the water utilities.

In another study of the impact of transactional and transformational leadership styles on organisational performance using a water utility in Nigeria, Ejere and Absalom (2013) found that although a transformational leadership style had a stronger effect on organisational performance of the water utility than the transactional leadership style, both had a significant positive relationship with organisational performance. They recommend that a mix of transactional and transformational leadership styles should be implemented taking into account the context and task assigned to the employees.

Evidence of the importance and effect of transformational and transactional leadership styles on water resource management shows that a combination of both leadership styles is critical for water management organisations. Based on this and evidence of its essential nature, a leadership dimension is proposed for the new WMIS success model. In the next section, I will discuss the effect of both leadership styles on IS success in general and its importance to the WMIS success.

3.5.2 Effect of Transformational and Transactional Leadership on IS Success

Many studies have been carried out on the effect of these two leadership types on information systems implementation and success.

Cho, Park, and Michel (2011) examined the impact transformational leadership has on IS success via systems self-efficacy and perceived organisational support in Korean multi-national bank. The results of the study showed that transformational leadership was significantly related to IS user satisfaction and perceived usefulness. It was also significantly related to perceived organisational support and the system self-efficacy. One of the theoretical implications of their study was the fact that there was a lack of research on the effect transformational leadership on IS success in non-Western cultures. In a study on the effects transactional and transformational leadership styles have on perceived usefulness in the after-sales service department of a Dutch high-technology company, Schepers et al. (2005) found that transformational leadership influenced perceived usefulness of the technology. They did not find any influence of transactional leadership on the perceived usefulness of the technology. Sánchez, Kappelman and Prybutok (2004) carried out a study to assess the effect of leadership on IS success using city government employees in the United States of America (USA). The study used the known Malcolm Baldrige National Quality Award (MBNAQA) which incorporates both transformational and transactional leadership. They studied both organisational and IT-based leadership effect on IS success. The findings showed that both transformational and transactional leadership positively affected IS success based on the approach taken whereas IT-based leadership also positively affect IS success.

It is evident that both transformational and transactional leaderships have a significant effect on the success an information system. While some of the studies were on individual effects of transformational or transactional leadership on IS success, others had both in the same study. The recommendation from literature, however, is a merge of the two leadership styles is desirable (Avolio et al., 1999; Bass & Avolio, 1996; Wright & Pandey, 2010).

3.5.3 Leadership Importance on WMIS Success

Leadership has been acknowledged as one of the most important aspects of sustainable water resources management in general (CSIR, 2010; Grigg, 2011; Lindfors, 2011). Its effect on the structures and everyday activities of water resources management is well documented in the WRM literature (Borchardt et al., 2016; Grigg, 2016; Pollard & du Toit, 2011). The effect of any of the leadership styles on WMIS success has however not been studied in the literature. Schaub-Jones, Souza and Mackintosh (2014) provide lessons from implementation of ICTs applications in the water sector of three countries – South Africa, Tanzania and Mozambique. As part of lessons learnt they recommend leadership commitment in the implementation of new ICTs in the water. The study did not specifically set out to understand leadership effect on ICT success.

This study will thus be an important step in understanding the effect of these leadership styles on WMIS success. Along with the leadership, the organisational structure and environment of water management organisations are also considered critical to the success of water resources management. In the following section, I discuss these two critical dimensions of water management organisation.

3.6 ORGANISATIONAL STRUCTURE AND ENVIRONMENT OF WATER MANAGEMENT ORGANISATIONS

This section discusses the organisational structure and environment effect on IS success. Each subsection briefly discusses the concept and then proceeds to provide evidence from the literature.

3.6.1 Organisational Structure

Organisational structure comprises a set of goals which have to be achieved by the organisation, tasks performed to achieve these goals, set of actors assigned to and who undertake or process these tasks and a way of communicating information between the relevant actors (Malone, 1986). In essence, organisational structure is about hierarchies, functions/tasks, communication and performance(Carley, 1991), it is also seen as a mechanism for information processing (Sor, 2006), and in other cases as a principal instrument of organisational design (Sauer, College, & Willcocks, 2003). The arrangement of an organisation's structure should be in such a way that it serves the strategy in place and the strategic priorities (Doherty, Champion, & Wang, 2010). Sauer et al. (2003) state that organisational structure and technology do complete each other, in the sense that, where structures create boundaries, technology traverses these boundaries allowing for complex processes to be managed competently.

The water management organisational structure as discussed in Section 2.4.2 consists of stakeholders and their respective functions and responsibilities occurring at three levels – national, provincial and local – of management. Various WMIS have been implemented at the various levels with the aim of aiding these functions and responsibilities in light of the information flow hierarchy shown in Figure 2-5.

There have been studies to understand the effect of organisational structure on information systems implementation success and vice versa. One of the earliest studies on the subject matter was by Ein-Dor and Segev (1978). They identified and suggested a contextual scheme for organisational context variables that affect the success and failure of information systems. The authors categorised the variables as uncontrollable, partially controllable and controlled. Organisation structure was classified as one of the uncontrollable variables of information systems success. Raymond (1990), using the Ein-Dor and Segev (1978) conceptual framework, the author conducted a study of organisational context on the success of information systems on 34 small and medium-sized manufacturing companies. In the study, the organisational context consisted of factors namely organisation size, maturity, resources, timeframe and IS sophistication. The result showed that organisational timeframe and IS sophistication affect the success of IS success via user satisfaction and use, while size, maturity, and resources mediated IS sophistication. The author concluded that contextual variables in the organisation had a significant influence on IS success.

Hussein, Selamat, Anom, Karim, and Mamat (2005) studied the influence of organisational factors on IS using perceptual measures in the Malaysian e-

Government agencies. The organisational factors consisted of decision-making structures, top management support, goal alignment, managerial IT knowledge, management style and resource allocation. The findings from the study showed that all the factors supported all the success factors that were investigated and hence the conclusion was that organisational factors – many which form part of an organisation's structure – affect IS success.

Rezaei, Asadi, Rezvanfar and Hassanshahi (2009) investigated the influence of organisational factors has on the success of MIS via perceptual factors. The study was conducted using data collected from agricultural extension managers in Iran. The findings from the study showed that structure had a significant impact on the success of the system.

It has been shown from the evidence presented from various studies that organisational structure has affects the success of information systems. The structure of an organisation is broad, and as seen, each of these studies has studied aspects of the organisational structure and their effect on the success of information systems. This study will provide insight into the effect of water management organisational structure on WMIS success and add to the body of knowledge on the subject matter.

3.6.2 Environment

The environment of an organisation constitutes factors – physical and social – that influence the decision-making behaviours of individuals in the organisations (Baumüller, 2007; Duncan, 1972). Differentiation is generally made between internal and external environments.

Baumüller (2007) opines that these external conditions influence what comes into the organisation, which directly affects how the outputs emanating from the organisation's activities are received. In the end, internal operations within the organisation are affected. There is an inherent uncertainty within an environment, and the perception surrounding this uncertainty increases with the complexity and rate of environmental change (Babalhavaeji & Farhadpoor, 2011; Duncan, 1972).

In the South African context, for example, water management organisations are affected by their external environment. Standards like the ISO/SANS 17025 and others by external organisations like the DWS, DoH, SANAS, SABS, WRC, IMESA and SALGA influence the operations and internal activities. Take the everyday activity of water quality monitoring, for example, the standards which have to be met for water quality reporting affects the WMIS use and outputs – reports, data quality and other system attributes. Again other internal environment factors have been known to affect aspects such as accreditation and purchasing of software licences (Balfour et al., 2011; Broodryk & De Beer, 2004). Of interest to this study is how both these internal and external factors affect the organisation and the success of the WMIS. Many IS studies have been conducted in this regard.

Buruncuk and Gülser (2004) in a study of factors affecting the success and failure of information systems implementation, found that some internal and environment factors (environmental dynamism and competition) affect IT success in companies. They further state that, there is a close relationship exists between the environmental factors and IT success and failure. The relationship is attributed to the fact that external environmental factors require the firm to utilise IS application strategies to survive. These environmental uncertainties tend to affect IS application in the firm hence the importance of environmental dynamism factor.

Lee, Lin and Pai (2005) examined the influence of environmental and organisational factors on internet-based inter-organisational systems (IIOS) planning success. The findings showed that one of the environmental factors, which was external, and two organisational factors influenced IIOS planning success. This affects the overall IIOS to organisational performance.

Alreemy, Chang, Walters and Wills (2016) investigated the critical success factors (CSFs) for information technology governance (ITG) and created success factors for ITG framework. Their findings produced ten main categories − Stakeholder involvement, Management support, Financial support, Organisational effects (internal), Strategic alignment between IT and business, IT staffing management, IT structure, Environment effect (external), Managing the implementation and Preparation − for this framework. The authors assert that the external effects and environment should be considered right from the onset. These external effects include the external policies and regulatory requirements.

Indeed, from the different IS implementations, environment factors, both internal and external, play an important role in its success. Notably, the literature presented in this section also shows the importance of the water management organisation environment on the process and its subsequent effect on the WMISs.

3.7 RESEARCH GAPS AND OPPORTUNITIES

Evidence from the literature presented showed that IS success evaluation is a highly-valued research domain, and it is dominant in sectors as health, education and other disciplines with the availability of empirical evidence to back. Although the importance of IS to water resources management is acknowledged as observed in the related work, there is no research has been conducted on WMIS success.

The extant related work has laid the foundations and highlighted gaps that motivated the research. A summary is presented below.

1. Water Resources Management is an arduous task set in a complex social environment and requires:

i. An interdisciplinary approach involving multiple stakeholders
ii. Information and use of the information that traverses disciplines
iii. Committed leadership that influences the organisational structures and adherence to environmental factors that are crucial to its management

2. Water Management Information Systems if adequately implemented can enhance the management of water resources by:
   i. Supporting everyday water management operations associated with the many activities in this complex socio-technical setting
   ii. Supporting the infrastructure planning aspects that present itself
   iii. Providing means of data collection, and presenting relevant, accurate and easily accessible information for the decision-making process
   iv. Supporting the decision-making processes associated with everyday activities and task, and future planning scenarios
3. Need to understand the factors affecting the implementation of WMIS given the purpose and nature of WRM
   i. Factors – system and organisational – affecting WMIS implementation and success have not been fully understood and explored in developing countries
4. The existing studies on WMIS:
   i. Presents the various implementations that exist and what they are being used for
   ii. Presents challenges associated with implementation in the contexts
   iii. Presents lessons learnt where they exist
   iv. Does not provide a holistic understanding of success factors that brings all organisational, system and other factors to bear.

The identified gaps presented then suggested the need to understand factors affecting WMIS success given the nature of water resources management processes, activities and its multi-stakeholder environment. Subsequently, this led to the research questions posed in Section 1.2. The following questions were asked?

RQ: What system and organisational factors can be used to develop a model for WMIS success that supports efficient water resources management?

RQ 1. What organisational factors affecting the organisation's functions determines WMIS success?

RQ 2. What system factors determine the success of Water Management Information Systems?

RQ 3. What IS success models can be used to derive a WMIS success model?

The purpose of this study was thus to answer the research questions posed. A model for WMIS success that incorporates these factors within the water resources management context needs to be developed, validated and tested.

3.8 SUMMARY

The chapter provided the theoretical background of the WMIS model development. It began with a discussion on what success and failure mean, and its operationalisation in the WRM context. Further, what WMIS success evaluation entails was presented. Following on from that, I present a discussion on different IS success evaluation models with emphasis on the DeLone and McLean IS success model and the HOT-Fit framework.

The discussion continued with leadership and leadership styles. Two forms of leadership – transactional and transformational – were presented. The importance of these two leadership styles to the significance of WMIS implementation and the addition of leadership to the WMIS model was justified. The chapter further discusses organisational structure and environment. The inclusion of organisational structure and environment justified. Finally, the research gaps that arise based on this discussion and the literature review are presented.

4 DEVELOPING THE MODEL

4.1 INTRODUCTION

This chapter discusses the development of the WMIS success evaluation model. The sections that follow elaborate on the model basis – constructs, the variables that constitute the constructs and choice of these variables on constructs for the WMIS.

In conclusion, the chapter introduces the derived WMIS success model which is an enhancement of the base model. This enhanced model combines some constructs of the base model, introduces new constructs and then contextualise it for the water sector. Within this context, a number of hypotheses are proposed, and each of the hypothesis is explained. This provides a thorough explanation of the relationships existing between the various constructs.

4.2 SELECTION OF MODEL BASES AND CONSTRUCTS

Within the IS and WRM literature, there is no known model which has been developed and validated for the evaluation of WMIS success.

What constitutes WMIS success as presented in the water resources management literature has already been discussed in Section 3.2 In developing the WMIS success model, this study explored the literature to determine a model that can be adapted. The study adopted a base model – the HOT-fit framework (Yusof, Kuljis, et al., 2008) – which was developed for IS evaluation in the healthcare.

According to Liu et al. (2012), development of a model that attempts to measure must be based on a theoretical specification that is well founded. Developing this model on existing models, thus not only contextualises the model but more importantly uses validated constructs from well-established models (Boudreau, Gefen, & Straub, 2001). The models discussed in the previous chapter have been studied and validated in the IS literature thus meets Boudreau, Gefen, and Straub's assertion. There has not been any study in the IS literature particularly on the evaluation of IS success in the water sector. This provides operationalisation of constructs and empirical evidence in this context.

The HOT-Fit framework maintained some constructs from the DeLone and McLean IS success model as seen in the previous chapter. Similarly, this study maintains constructs from the human, technology and organisation aspects of the HOT-Fit framework. However, what makes this model different is the introduction of a Leadership construct and two outcomes – WMIS Use for Water Management Decision-Making (WDM) and WMIS for Water Management (WMO) – that represent the net benefits from the base model. In doing so, this study benefits from the validation of these constructs in previous IS studies. The outcomes are discussed in the later sections of this chapter. In the model proposed by Yusof et al. (2008), the net benefits dimension used clinical outcomes measured through morbidity, mortality and other measures like quality of care and other outcomes.

The outcome variables in the model are based on the extensive literature on water management and water management decision-making and as elaborated on in Section 2.6.3 and initial scoping conducted with water managers within the City of Cape Town and the Department of Water and Sanitation (DWS) in Cape Town. These sources provided information on general and contextual water management operations and decision-making. In choosing a base model for this study, an important question to be answered was, what factors influenced the management of water resources at the operational level? This was important because the study concentrated on the everyday management of water resources. A thorough discussion is found in Chapter 2.

The water resources manage literature, and initial discussions with some stakeholders served as a guiding lens in understanding what should be included in evaluating the success of the WMIS in general. The net benefits to be derived from the WMIS, system considerations and the overall factors from an organisation perspective resulted from the earlier submission (Abdullaev & Rakhmatullaev, 2014; Dent, 2010; Giupponi & Sgobbi, 2013; Mysiak et al., 2005; Rossouw et al., 2005; RSA, 1998b; Souza et al., 2009).

The WMIS success evaluation model will thus comprise a set of constructs that represent the system and organisational, and outcome constructs, WMIS for WMO and WMIS for WDM which is discussed in Section 4.3.1. The distinction between the two outcome choices is made clear from the discussion presented in Section 2.6.3, and they served as the proxy for WMIS success (this represents net benefits from the base model). The system factors which are discussed in Section 4.4.1 will include WMIS System Quality, WMIS Information Quality, Service Quality, System Use and User Satisfaction and finally, the broader organisation factors will consist of Leadership, Structure and Environment.

Each of these constructs is justified in Section 4.3, and a set of hypotheses are formulated via the relationships existing between these constructs.

4.3 OPERATIONALISATION OF THE MODEL

To operationalise the chosen model, there is the need to elaborate on the constructs and various constituents of the new model. This requires casting the various constructs and definitions in context and exploring the various related measures.

The sections that follow provide justification for each of the constructs – Net Benefits (WMIS for Water Management Operations and WMIS for Decision-Making), WMIS System Quality, WMIS Information Quality, Service Quality, User

Satisfaction, System Use, Leadership, Structure, and Environment – using the IS success evaluation and water management literature as guiding lenses. Water management outcomes are decision-based as discussed in Section 2.2. The section that follows immediately commences with the justification for the outcome or net benefits constructs.

4.3.1 Net Benefits or Outcome of the Model

WMISs are employed for the enhancement of water management at all levels. Yusof et al. (2008) assert that the benefits of such systems can be at the individual level, organisational level or the whole sector or industry in which the system has been employed. Management of water involves tasks and processes that are critical to both the management organisation and consumers. Notably, the use of the WMIS has benefits and outcomes that directly affect tasks, processes – water monitoring and others – and water management decision making (Abdullaev & Rakhmatullaev, 2014; Mongi et al., 2016).

Based on the discussion from the water management literature, this study proposed two distinctions in the net benefits dimension – WMIS for Water Management Operations (WMO) and WMIS for Water Management Decision Making (WDM). These two constructs affect the process at the organisational level and overall decision-making at the organisational, municipal, provincial and national levels respectively. Concerning the WMIS for WMO construct, the study looks at variables such as the use and the impact of the system on operations, monitoring and administration which is part of the important everyday water management process. Water management calls for data and information heterogeneity of water data and transparency and inclusivity. WMIS use for these purposes is considered crucial to the management of water resources as discussed in Section 2.7.

In the sections that follow, the study elaborates on the two distinctions and justify the two constructs.

4.3.1.1 WMIS for Water Management Operations

As discussed earlier, WMIS use for operations and management of water resources has become essential than ever before. There is a range of WMIS uses at all levels of the water management structure, to efficiently and effectively manage the resource. In the water management literature, many studies have highlighted WMIS use for water management operations at all levels (Abdullaev & Rakhmatullaev, 2014; Aher et al., 2014; Anzaldi et al., 2014; Badjana et al., 2015; Rivett et al., 2013).

WMISs are being implemented in many instances to enhance the everyday operational, planning and administrative activities of various water management organisations for efficiency (Abdullaev & Rakhmatullaev, 2014; Anzaldi et al., 2014). Some of the everyday operations involve the monitoring of water quality (Rivett et al., 2013), water demand and use (Jacobs, 2008) and infrastructure maintenance and planning (Arsene et al., 2012; Zeb et al., 2012). These are critical areas of the overall water management sector, and WMIS enables water manager's and relevant stakeholder's to manage the resource effectively.

Water is a shared resource and stakeholders – managers and the citizenry – require access to relevant information on water resources and to also submit data and information on concerns such as quality of water, access and others and also to make their opinions on activities that affect their access to the resource known (Nakayama, 2002). Improving transparency of water resources management is thus considered an undertaking that could bring about not only sustainable water management but inclusivity and participation from all and sundry who utilise the resource (Abdullaev & Rakhmatullaev, 2014; EEA, 2014; Pereira et al., 2003). In that regard, WMIS is considered a tool that can bring about transparency and accountability (Rivett et al., 2013). It is thus important that information systems that are used for water management enhance transparency and inclusivity through the accessibility of the relevant data and information.

Another important aspect of WMIS use in water management is the ability to aid water management institutions to acquire and manage water data heterogeneously. Within the water management literature, it is acknowledged that the lack of water information presents challenges to water managers and stakeholders at all levels of water management (Baisch, 2009; Messervey et al., 2015). WMISs have been acknowledged to address this gap, and its use should have the ability to aid data and information heterogeneity as well as support subsequent knowledge creation. It also facilitates easy access and sharing of information among different stakeholders and enhances collaboration (Badjana et al., 2015; Gerlak et al., 2011; Mongi et al., 2016).

An important aspect of water management is water quality. This involves a systematic inspection and testing of water for human consumption and use. During the process, there is the collection of data for analysis to aid in the management of this aspect and other important water management operations (Lindfors, 2011). Water quality data consists of varying data types – chemical, biological, toxicity, PH and others – the forms part of the larger water quality process. Also, water quality monitoring plays a crucial role in aiding authorities to identify public health risks and ensuring water safety (Kumpel, Peletz, Bonham, Fay, & Cock-Esteb, 2015).

Further, the data and information acquired not only provides the relevant information for daily water operations and compliance, but it also feeds into both national and water global policies, guides and regulatory frameworks that are developed and are constantly being revised (Rivett et al., 2013; UNEP, 1997). Using WMIS for water quality monitoring is regarded as a critical aspect of the water management process. In determining the success of such WMISs, its primary purpose of enhancing water management operations must be duly captured in the assessment model.

4.3.1.2 WMIS for Water Management Decision-Making (WDM)

Decision-making involves the selection of an alternative from an available set of other options to solve a unique problem (Al-Mamary, Shamsuddin, & Aziati, 2013). Decision making in water management is central to the entire management process and is known to be complex. Making informed decisions based on the already scarce water data is considered a challenge (Dent, 2010). However, it is always a pressing need considering its importance. Water management involves different processes and stakeholders at different levels. Literature provides a body of evidence regarding decisions that occur at the various stages and the importance of these decisions within the water management process (Loucks, 2000; Miller et al., 2004). The water sector has become highly reliant on information technology to water management decision-making at all levels (Abdullaev & Rakhmatullaev, 2014; Miller et al., 2004; Mysiak et al., 2005; Rossouw et al., 2005). Decision making in water management is an everyday process that affects the way the resource is managed continuously and in a highly dynamic environment. In essence, water management decision outcomes such as water quality, water use, water demand management, water infrastructure planning and others are significantly affected by the direct and indirect use of WMIS for the tasks and processes with the water resources management (Badjana et al., 2015; J. Davis, Crow, & Miles, 2012; Mongi et al., 2016).

WMIS has proven to provide many benefits to the water management decision-making process. Management decision making has been enhanced with the availability and access to data and information in an integrated manner than before (Miller et al., 2004). Such readily available and accessible information is considered an important part of making quick and well-informed decisions about the resource (Timmerman, 2015). Not only is the information provided by the WMIS relevant, water managers and decision makers within the sector believe it brings increased confidence in aspects such as water quality (Rivett et al., 2013). Decision quality is thus improved through the use of WMIS during the decision-making process. Further, policy formulation, legislation and regulations are central to WRM, and these rely highly on data and information generated and the knowledge created from the WMIS (Dent, 2010; Timmerman, 2015). Proper decision making for resources management relies on information and complex knowledge products that are in part outcome of the WMIS use (Harris et al., 2001).

In summary, the above discussion justified use of WMIS for water management decision making as one of the outcome variables. It further elaborated on the constituents of the WMIS for WMDM construct with evidence from the literature.

4.4 FACTORS INFLUENCING SUCCESS OF WATER MANAGEMENT INFORMATION SYSTEMS

As already outlined, this study aims at developing a model for WMS success for water management. The background and motivation provided showed that such a model is affected by both the system and organisational factors found in water management organisations. I will discuss these factors and support them with the literature on their inclusion in the sections that follow.

4.4.1 System Factors

In evaluating the success of an information system within an organisation context, the artefact cannot be viewed as a separate entity. They do not exist in vacuums but in defined settings that ascribe meanings and levels of engagement to their use. These systems are often implemented to support activities considered important to the organisation or individuals (P. Zhang, Scialdone, & Ku, 2011).

In understanding how these systems have impacted the contexts within which they are placed, three common system measures have discussed extensively in IS literature (Hellstén & Markova, 2006; Seddon, 1997). System quality, information quality and service quality are dimensions that have elicited extensive discussions from literature (Gable et al., 2008; Hellstén & Markova, 2006; Petter et al., 2008; Rai et al., 2002; Seddon, 1997; Yusof, Kuljis, et al., 2008).

The sections that follow discuss and justify each of these dimensions from both IS and WM contexts.

4.4.1.1 WMIS System Quality

The nature of water means facets of its management requires the need to follow standards set by water utilities and independent bodies responsible for public health (Kumpel et al., 2015). These requirements and standards move down the ladder to even the reports generated as output. These are mandatory and must be made part of the WMIS systems implemented. The quality of a system thus provides a way of measuring how the desirable characteristics and inherent features of the information system impact its success (Petter et al., 2008; Yusof, Kuljis, et al., 2008).

A number of studies in the water management and IS literature have explored system quality (Delden et al., 2011; Gable et al., 2008; Hellstén & Markova, 2006; Miller et al., 2004; Mysiak et al., 2005; Pérez-Mira, 2010; Rai et al., 2002; Souza et al., 2009). Some of the common variable measures used for system quality include ease of use, availability of functionalities, response time, system flexibility, completeness, user-friendliness and others (Gable et al., 2008; Hellstén & Markova, 2006; Pérez-Mira, 2010; Rai et al., 2002).

The quality of the system was considered one of the aspects that contributed to the success of a WMIS (eWQMS) implemented for water quality monitoring by WSAs in South Africa (Souza et al., 2009). In this case, the measures for quality of the WMIS were the ease of use, robustness, reliability and secure nature of the system. The authors state that these were relevant to the successful outcome of the WMIS for the functions and responsibilities within the respective water management organisations.

Other studies in the water sector have also highlighted the quality of the systems an important aspect of WMIS implementation success. Available functionalities, user-friendliness, system security and reliability were also some of the context-specific measures found in the water management literature on WMIS (Miller et al., 2004; Rossouw et al., 2005). The WMIS requires functionality that will provide the needed support for the various tasks within the water management processes (Badjana et al., 2015). Badjana et al. (2015) identified the functionality of a WMIS as an important part of system quality in their study of information systems for integrated land and water resources management in West Africa. They acknowledge, however, that the lack of functionality available for the system implemented affected access to information, providing the needed support for research support of the multiple stakeholders, and the decision making processes.

On account of this discussion, WMIS system quality was included as a system construct that affects WMIS success.

4.4.1.2 WMIS Information Quality

Information is considered the crux of water management and all its decision making. Both the availability of the information and quality of the information available is very important in water resources management(Abdullaev & Mollinga, 2010; Badjana et al., 2015). , Horne (2015) posit that WMIS should be focused on data that will enable the answering of policy decisions, assist stakeholders in effectively making relevant decisions, and also aid businesses and government to address the risk associated with water-related events.

In the IS success literature, information quality is considered an important dimension in evaluating the success of information systems and is seen as a key dimension of user satisfaction (DeLone & McLean, 2003; Doll & Torkzadeh, 1988; Gable et al., 2008; Hellstén & Markova, 2006; Ives, Olson, & Baroudi, 1983; Petter et al., 2008). Information quality with regards to WMIS will be the information output – water quality results, water use quantity and demand, fault and leakage information and reports, assets, infrastructure information and others – from the implemented system (Curry et al., 2014; Gumbo, Juizo, & van der Zaag, 2003; Johnson, 2003; Messervey et al., 2015; Stewart, 2015). Examples of information quality measures in the IS literature are information accuracy, relevance, reliability, consistency and completeness (Gable, Sedera, & Chan, 2003; Gable et al., 2008).

The availability and quality of information in support of water management at all levels has been acknowledged (Quin, 2012; Souza et al., 2009; Stewart, 2015; Timmerman, Ottens, & Ward, 2000). Concerning WMIS, the water management literature has highlighted accessibility, accuracy, security, traceability and information standards as important information quality measures (Dent, 2010; Miller et al., 2004; Stewart, 2015). Specifically, standards like the ISO 17025 detailing how water tests, sampling, inventory, reports, output documents and others must be handled are critical to water quality management standards (Broodryk & De Beer, 2004). Stewart (2015) states succinctly that where there is the need to safeguard lives, confidence is required in the accuracy and quality of the data in question which depends on the requirements outlined.

Earlier research by Miller et al. (2004) on ICT in watershed management decision making state that the availability and access to information allow stakeholders to use current information, perform analysis, and make a decision on complex issues. They further suggest that the success of decision making is dependent on the information available through such systems. Dent (2010) also posits that access to data and information is a crucial requirement of WMIS success. In a study on the role of WMIS in water management in South Africa, the author acknowledges that the accessibility to information is vital to stakeholder decision making as it fosters transparency and integration. Abdullaev and Rakhmatullaev (2014) also acknowledged that the content, format and interface for the accessibility of such data were the focus of some data management interventions when they studied data management for IWRM in central Asia. Other studies have also acknowledged the importance of information quality to WMIS success (Chao et al., 2015; Giupponi & Sgobbi, 2013; Souza et al., 2009).

The discussion above justifies the inclusion of WMIS information quality as construct affecting the success of WMIS.

4.4.1.3 Service Quality

The success of an information system within an organisation as evidenced from the IS success studies shows its inherent link to the services provided by IS support personnel or department (Jiang, Klein, Parolia, & Li, 2012; Petter et al., 2008). One of the authors to introduce service quality into the IS context were Pitt et al. (1997) and Kettinger and Lee (1994). This dimension of IS success measure is perception based and one can understand given its origins from marketing. However, its adaptation in the IS literature is widespread and is seen as an essential aspect of measuring IS success (Song & Letch, 2012).

Some measures have been applied in IS to understand service quality. Majority of the studies have highlighted reliability, responsiveness, assurance and empathy as the significant measures (Jiang et al., 2012; Landrum, Prybutok, Zhang, & Peak, 2009). For example, to determine how reliable a service is, some of the measures are – users' opinion on whether the service was done by the promised time, dependability and sincerity in solving user problems. Regarding responsiveness, users' opinions on willing to help, and promptness are sought. For assurance, one can find out their opinions on whether the personal have necessary knowledge (Jiang et al., 2012).

During the initial discussion phase of the research, there was a distinction in the service quality provided for the WMIS in the City of Cape Town Water Services Department. The departments where these systems were implemented, had experienced service provision from external consultants and more recently internal personnel. The external service quality was a part of the existing bespoke software system that had been implemented. Challenges and new policies required the internal provision of service quality to address the shortfalls of having external consultants. Service quality observations are discussed extensively in the results and conclusion of the thesis. Also, support of WMIS is acknowledged to bring about success in the system use (Souza et al., 2009). Based on this insight, part of the questions included their opinion on the effect of internal and external service quality on their use of the system.

In summary, there was strong justification from the IS literature and empirical evidence from the earlier discussion with relevant stakeholders and system administrators to include service quality in the model.

4.4.1.4 User Satisfaction

According to Ives et al. (1983), there is always the need to justify the cost of information systems pre- and post-implementation. Stakeholders involved require mechanisms to determine this need and the functioning of the information system post-implementation. User satisfaction is one of the widely used measures of information systems success in the literature (Gable et al., 2008; Petter et al., 2008). It measures a user's perception of the extent an information system meets their needs and expectations (Ali, 2012; Ives et al., 1983). It is subjective and is based on an individual user's satisfaction (Yusof, Kuljis, et al., 2008).

Evidence suggests a strong relationship between user satisfaction and other constructs particularly information quality and net benefits which affect the overall success of an information system (Iivari, 2005; Kulkarni et al., 2006; Roky & Al Meriouh, 2015; Scheepers, Scheepers, & Ngwenyama, 2006; Wu & Wang, 2006). The evidence suggests that there is a positive impact of user satisfaction on net benefits at the individual and organisation levels (Kulkarni et al., 2006; Scheepers et al., 2006). Some of the variables used in measuring user satisfaction were satisfaction with functions of the system, perceived usefulness, task satisfaction, satisfaction with information needs and decision-making satisfaction (Ives et al., 1983; Yusof, Kuljis, et al., 2008).

Regarding user satisfaction with WMIS, several variables are used in the water management literature. Satisfaction with functionality, data capturing mechanisms, the credibility of information, ease of use and timeliness of the information were some of the measure found in the water management literature (Rossouw et al., 2005; Souza et al., 2009).

User satisfaction is thus an important construct that is included in the model for WMIS success evaluation.

4.4.1.5 System Use

System use is one of the measures of IS success evaluation commonly found in the IS literature (Bailey & Pearson, 1983; Doll & Torkzadeh, 1988; Irani & Love, 2008). System use has to do with the degree and manner in which system capabilities are utilised (Petter et al., 2008). Studies have shown the positive correlation between system use and other constructs that affect both individual and organisational levels (Gable et al., 2008; Petter et al., 2008). It is understood that system use brings about efficiency and productivity at both individual and organisational levels. Petter et al. (2008) state emphatically that, system use is often criticised or ignored in the measure of IS success. However, based on their conclusion from the empirical evidence, it is an important measure of IS success that influences the benefits of the IS. There is enough evidence though to show that the system use construct plays an essential role in understanding IS success (Burton-Jones, 2005; Gable et al., 2008; Rai et al., 2002).

Studies in the IS success domain provide variables for measuring the system use construct. Some of these are the frequency of use for a particular purpose, nature of use, level of use, the extent of use, knowledge and expertise, motivation to use and acceptance (Petter et al., 2008; Yusof, Kuljis, et al., 2008).

The water management and information systems literature does not provide much regarding measure for WMIS use. In part, this study relies on measures from the general IS literature and contextualised on the purpose of WMIS implementations in the water management literature (Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Dent, 2010; Giupponi & Sgobbi, 2013; 2001; Souza et al., 2009). The use of WMIS as seen in the literature listed above are mainly for water management and decision-making. This distinction is highly relevant because it is suggested that in measuring system use, it is important to reflect the variety of use and in a multidimensional to capture various key performances associated with the use of the system (Ali, 2012; Doll & Torkzadeh, 1998). The result is a way of understanding the true effect an implemented system has on an organisation.

Acknowledgement in the water management literature on the need to use information technology in water management decision-making and water management processes, and operations for sustainability and efficiency, support the multidimensional approach – suggested above – to system use. Hence, WMIS Use for Water Management Operations and WMIS Use for Water Management Decision-Making (WDM) are proposed in the model for the study.

4.4.2 Organisation Factors

In the past, much emphasis was placed on the information technologies that were required to support organisations. However, research has shown that consideration should be given to the management and organisation aspects that provide the environment for the use of these information technologies (Rossouw et al., 2005). Water management structure, environment, and leadership play an important role in how water institutions operate and their performance in general (Grigg, 2011; Saleth & Dinar, 2005).

The sections that follow elaborate and justify the chosen constructs in the context of WMIS within water resources management.

4.4.2.1 Leadership

The role of leadership in IS implementation, in general, has been widely acknowledged (Barzekar & Karami, 2014; Cresswell, Bates, & Sheikh, 2013; Ke & Wei, 2008; Shao, Feng, & Hu, 2012). From the IS literature, Shao et al. (2012) affirm that top-management play such an important role in reinforcing norms that auger for the use of technology in an organisation. Also, the behaviour of leadership in how it manages the organisation regarding its support is relevant for IS implementation, adoption, use and success (Ali, 2012; Cresswell et al., 2013).

The water management literature has highlighted the role of leadership in water management processes (Mysiak et al., 2005). According to Grigg (2011), technical knowledge and methods alone do not provide enough solutions to water quality, water supply and other water scenario challenges that arise. Accordingly, leadership is a prerequisite to tackle barriers as coordination difficulties, ineffective laws, adhering to regulations and others. Part of leadership within water resources management involves exhibiting certain qualities and providing the needed support in the use of WMIS.

In understanding the effect of leadership on WMIS use for water management, the study falls on literature in both water management and IS for leadership measures. Theory of leadership is presented in Section 3.5 of the previous chapter.

A standard measure of leadership adapted for many IS studies is based on the Multifactor Leadership (MLQ) questionnaire, MLQ 5X (Avolio et al., 1999) or other forms (Dussault et al., 2013) that evaluate leadership styles. Often these measures look at mainly transformational and transactional leadership behaviour as seen in the literature review section. This study drew on measures from the work of Dussault et al. (2013), Avolio et al. (2003; 1999, 2009) and based on the assertion by Grigg (2011) discussed earlier. The discussion on leadership styles in the water resources management literature is presented in Section 3.5. This provides a way to understand the effect of leadership on WMIS use. The leadership construct which has been introduced extends the one by Yusof et al. (2008).

On the evidence of the above discussion and justification on leadership presented in Section 3.5, this construct and respective measures are added to the model for WMIS success.

4.4.2.2 Structure

An organisation's structure as elaborated in Section 3.6 is important in how processes and tasks are undertaken, and how information is communicated among actors and processes. The structure of an organisation is known to affect information technology implementation and use, and vice versa (Lucas Jr. & Olson, 1994; Mirmasoudi, Farjami, & Pourebrahimi, 2012).

Within the water management structures, WMIS serves as a tool in coordinating information between the actors, integration and enhancing the process that takes place (Abdullaev & Rakhmatullaev, 2014; Harris et al., 2001). Collection of data and information is central to water management at all levels (Abdullaev & Rakhmatullaev, 2014). In operationalising and measuring the structure construct in this context, the study used communication, integration, goals and organisation strategy, infrastructure and culture seen from the IS and water management literature. For example, there is similar evidence that the information gathered through the WMIS enhanced the communication between the various stakeholders (Rivett et al., 2013).

Thus, structure is contextualised from the original model and used in this current model based on the justification provided.

4.4.2.3 Environment

The environment of an organisation like its structure affects the implementation and use of information systems. As seen in the extended literature on environment in Section **3.6.2**, these are factors or forces –internal and external – which influences how the organisation carries out its functions.

Yusof et al. (2008) provide some validated variables that serve as measures for the environment construct. Some of the examples of variables provided are financing, government, politics, localisation, competition, communication, and population served.

In this study, some of the measures mentioned above were used. During initial interaction with users, there was a consensus that the limited licenses that affect their use of the system can be attributed to financing. Another important environment variable is desired outcome of the WMIS based on external environmental factors. Other environmental factors are the standards requirements from institutions like DWS, SANS, IMESA, SALGA, WHO and different ISO standards.

4.5 CONCEPTUAL MODEL FOR WMIS SUCCESS MODEL (WSM) AND DEVELOPMENT OF HYPOTHESES

Based on the justification provided in the sections above, and the background presented in Chapters 2 & 3, this section proposes a model for evaluating the success of WMIS. The proposed model is developed on an elaborate justification from both the IS and water resources management literature. Mainly, it is developed from the base model, HOT-fit framework, which also derives from the DeLone-McLean Success Model and IT-Organisation Fit Model.

As discussed in Sections 4.1 – 4.4 the constructs were chosen to reflect the water management context with clear distinctions and modifications made to the model by Yusof et al. (2008). The water management literature provides strong evidence of the distinct ways information systems are employed in the water sector – water management and water management decision-making (Badjana et al., 2015; DWAF, 2001; Rivett et al., 2013; Rossouw et al., 2005; Souza et al., 2009). These two as described in Section 4.3.1 serve as the net benefits derived from the WMIS. The WMIS for water management decision-making construct provides a measure that speaks to outcomes such as the complex knowledge products; reports and documentation; policy, legislation and regulation; water quality, water demand and infrastructure decision outcome. WMIS for water management construct address the processes, tasks and goals within the water management organisations for which the WMIS was implemented. These include operational and water quality monitoring processes, administrative duties, integrating processes and task, data and information integration and enhancing transparency and inclusivity in the management of water resources.

In Section 4.4.1.3, the service quality constructs bring some insight to the fore as seen in the discussion. The initial interview phase provided insight on internal and external service quality. These two gave an understanding of the impact of providing system support to users when it is done by personnel who are onsite versus being outside the organisation or consultants specifically.

Another distinction made in this model is the separation of leadership from the structure construct and creating a new construct. This is based on the thorough discussion and justification presented in Section 4.4.2.1. The effect of leadership or top-management on the success of the use of WMIS has been further justified. Again, the effect of leadership on IS implementation in general in the IS literature has received a lot of attention as discussed in the same section.

Ensuring water safety is an important aspect of water management that is given a lot of attention. Waterborne disease is considered a health challenge globally according to the World Health Organisation (WHO). WHO provides a set of guidelines which have (WHO, 2005). WHO has developed guidelines in this regard and all water management institutions globally adhere to. South Africa has drafted its water safety framework; *Drinking Water Quality Framework for South Africa* (Hodgson & Manus, 2006). This is a quality requirement formulated to ensure water safety to all the citizenry. WMIS provides the means of acquiring and analysing water quality data needed for decision-making in this regard. The development and use of WMIS, in general, is a requirement of the South African National Water Act (NWA)(RSA, 1998b). The purpose for which WMIS is used and the consequences of how WMIS impacts on water management and water management decision-making are very important (Dent, 2010).

The sections that follow present justification for a set of hypotheses that are formulated for each of the constructs within the dimensions: system and organisation. Similarly, same is done for the WMIS for Management and WMIS for Water Management Decision-Making constructs which form the net benefits.

4.5.1 System factors

The system factors consist of five constructs from which a set of hypotheses are formulated. These hypotheses establish the relationship between the constructs within the various dimensions. The following hypotheses are proposed.

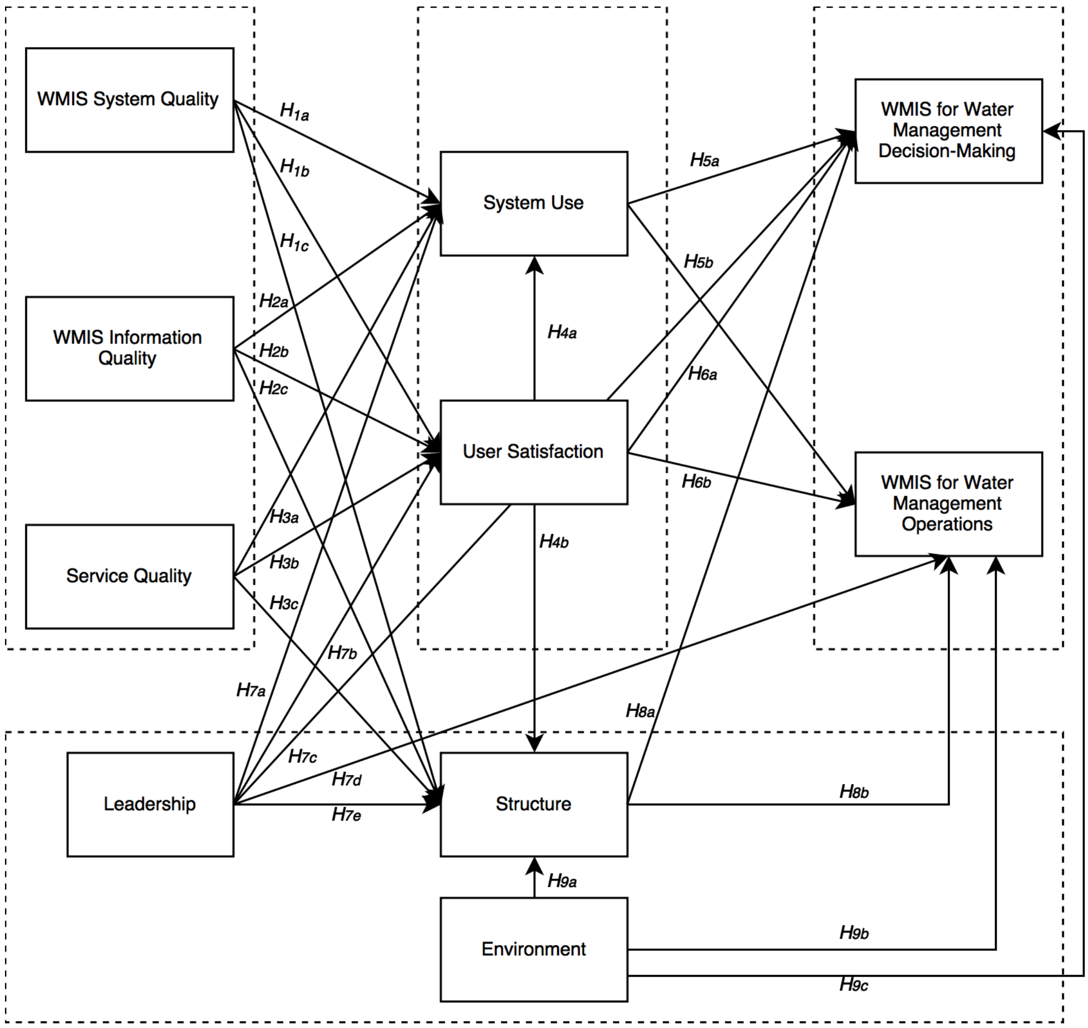

Figure 4-1: Proposed WMIS Success Model (WSM) with Hypotheses

4.5.1.1 H_{1a}, H_{1b}, H_{1c}: *WMIS System Quality has a significant positive effect on Use, User Satisfaction and Organisational Structure*

The importance of WMIS system quality to the success of WMIS has been treated extensively in Section 4.4.1.1. The success of WMIS as seen from both the IS and water management literature, has been attributed to system quality measures such as the perceived ease of use, perceived ease of learning, security, reliability and others (DeLone & McLean, 2003; Petter et al., 2008; Souza et al., 2009).

Hypothesis 1a: WMIS System Quality has a significant positive effect on Use

Based on evidence from literature, the overall system quality affects the use of the system and how satisfied the users are with the system. The relationship existing between system quality and use has been empirically confirmed in various sectors. Petter et al. (2008) reported missed support for this relationship at both the individual and organisational levels of analysis in multiple sectors. For example in an e-government services study, Qutaishat (2013) found a significant positive effect of system quality on the intention to use the system. Erlirianto, Ali and Herdiyanti (2015) implemented the HOT-fit – derived from – framework to evaluate an electronic medical record system in a hospital and found no significant effect of system quality on system use. There have been similarly mixed results from other studies in the literature (Al-Mamary et al., 2013; Choi et al., 2013; Iivari, 2005; Kulkarni et al., 2006). Indeed, results have been mixed for different contexts. However, the need to investigate this relationship is important for WMIS. Both the water management IS literature does not provide single empirical evidence of this relationship and this study seeks to add to the body of literature.

Hypothesis 1b: WMIS System Quality has a significant positive effect on User Satisfaction

Regarding the effect system quality has on user satisfaction, there is ample evidence supporting this relationship at the individual level. However, not much evidence exists at the organisation level (Iivari, 2005; Petter et al., 2008).Studies in knowledge management systems, for example, have confirmed a significant positive relation between system quality and user satisfaction (Kulkarni et al., 2006; Wu & Wang, 2006). In general, there is enough evidence within the IS literature to back the system quality-user satisfaction relationship (DeLone & McLean, 2003; Kim & Lee, 2014; Rai et al., 2002; Seddon, 1997).

The two hypotheses on system quality above are therefore included in the proposed model for WMIS.

4.5.1.2 *H_{2a}, H_{2b},H_{2c}: WMIS Information Quality has a significant positive effect on Use, User Satisfaction and Organisational Structure*

Information is no doubt one of the most important assets of any organisation particularly the water sector as discussed in **Section 2.5**. Further, the WMIS information quality construct as justified in **Section 4.4.1.2** is crucial to the overall success of WMIS. Information quality as seen from the literature has been measured using variables like usability, relevance, format, completeness, accuracy and reliability (Gable et al., 2003; Petter et al., 2008; Yusof, Kuljis, et al., 2008).

Information quality has been reported have effect or relationship with use and user satisfaction. These relationships are briefly discussed below.

Hypothesis 2a: WMIS Information Quality has a significant positive effect on Use

The relationship that exists between information quality and actual use of the system is common in the literature. There have been various operationalisation of the use construct at the individual and organisational levels (DeLone & McLean, 2003; Petter et al., 2008). The results have been mixed, some a having significant positive effect and others not (Iivari, 2005; Petter et al., 2008). Fitzgerald and Russo (2005) found information quality to have a positive effect on use in their study of the London Ambulance Service Computer-Aided Despatch System (LASCAD) while IIvari (2005) for instance did not in their study empirically testing the DeLone-McLean model of IS. DeLone and McLean (2003) argue that despite sentiments regarding use as a measure of IS success, it serves as an appropriate one nonetheless. Seddon (1997) argues for system use as a good measure of IS success in most cases.

Despite the mixed outcomes, this hypothesis is included in the study to understand the outcome of WMIS in the water sector context.

Hypothesis 2b: WMIS Information Quality has a significant positive effect on User Satisfaction

The effect of information quality on user satisfaction has been conclusively positive. Many studies have reported have found strongly correlation between the two constructs at the various levels – individual and organisational – of analysis and in different fields (Gorla, Somers, & Wong, 2010; Iivari, 2005; Kulkarni et al., 2006; Rai et al., 2002; Wu & Wang, 2006). At the organisational level though, not many studies have been conducted to make concrete conclusions (Petter et al., 2008). Similarly, a study by Caniëls and Bakens (2012) of a Project Management Information System (PMIS) on decision-making in a multi-project environment found a significant positive relationship between the two constructs.

WMIS Information Quality-User Satisfaction relationship is included in the study to understand this relationship in this context. It will add on to the limited literature on this relationship.

Hypothesis 2c: WMIS Information Quality has a significant positive effect on Organisational Structure

According to Al-Mamary et al. (2013), information quality leads to a decision maker's satisfaction in an organisation. Subsequently, it impacts the organisations regarding say processes or outcomes. Gorla, Somers and Wong (2010) confirm in previous studies that a significant positive relationship exists between information quality and organisational impact. Again, Caniëls and Bakens (2012) confirmed that the quality of information of PMIS had a significant positive effected on project managers' decision-making.

The quality of information from a WMIS is believed to influence the structure within water management organisations. The WMIS Information Quality – Structure relationship is thus included in the study.

4.5.1.3 H_{3a}, H_{3b}, H_{3c}: Service Quality has a significant positive effect on Use, User Satisfaction and Organisational Structure

The services rendered to users of information systems in an organisation is acknowledged to affect the success of information system in use and user satisfaction (Gorla et al., 2010; Pitt, Watson, & Kavan, 1995). The relationship between service quality – use and service quality – user satisfaction is justified below.

Hypothesis 3a: Service Quality has a significant positive effect on Use

This relationship according to Petter et al. (2008) has limited literature at all the levels of analysis. The outcome of the limited literature can be said to be mixed. Lai (2004) in an earlier study of service quality and perceived value's impact on satisfaction, intention and usage of short message service (SMS) found out that service quality is an antecedent of customer satisfaction which is has a significant positive effect on customers' behavioural use continuance. This seems to be confirmed by Kim and Lee (2014) who recently confirmed from their research on ubiquitous personal robot service that though perceived usefulness and user satisfaction has a positive significant effect on intention to use of a personal robot service, service quality was a significant antecedent to both user satisfaction and perceived usefulness. However, Halawi et al. (2008) did not observe a relationship between service quality and intention to use in their study on knowledge management systems.

The outcomes for this relationship is mixed with reports rather highlighting that it is often an antecedent to both user satisfaction and perceived usefulness which has a direct impact on use.

This hypothesis is added to the model to understand the effect on service quality on use with WMIS.

Hypothesis 3b: Service Quality has a significant positive effect on User Satisfaction

Researchers in the IS success space have shown the positive effect of service quality on user satisfaction (DeLone & McLean, 2003; Pitt et al., 1995; Seddon, 1997). Many studies more recently have also validated service quality – user satisfaction relationship. Akter, Ray and D'Ambra (2011) through an interdisciplinary approach evaluated the influence of mHealth service quality on perceived value, user satisfaction and continuance intention. Part of the conclusion was that service quality has an indirect impact on perceived value and satisfaction on mHealth service systems. Also, Choi et al. (2013) in applying IS success model to customer relationship management (CRM) system in health promotion centres found service quality influenced user satisfaction positively. Petter et al. (2008) claimed earlier that the outcomes had been mixed and in part could be attributed to the multiple methods researchers have used to measure service quality. Whereas some examine the characteristics of the support personnel, other training, and some cases vendor support at the organisational level.

Service quality is no doubt an important construct in IS success evaluation and must be factored in an IS success model (DeLone & McLean, 2003; Pitt et al., 1995). It is suggested that more research need to be carried out at the organisational level (Petter et al., 2008).

This hypothesis included in the study based on the above justification and the response from the initial interview carried with the users of the WMIS.

Hypothesis 3c: Service Quality has a significant positive effect on Organisational Structure

This relationship is not common in the IS literature. The only study in which this relation is validated is the study by Erlirianto et al. (2015) in health care.

The Service Quality provided in respect of the WMIS can influence how the aspects of the organisational structure perform certain task. The study, therefore, seeks to understand the Service Quality – Structure relationship in the water management organisation context.

4.5.1.4 H_{5a}, H_{5b}, H_{5c}: Use has a significant positive effect on User Satisfaction, WMIS for WDM and WMIS for WMO

As elaborated in **Section 4.4.1.5**, the use construct relates to aspects of the WMIS system such as how many times the system is used or frequency, purpose of use, skill level, motivation for use, knowledge of the system and others which within the literature provides varying results on their effect on user satisfaction and net benefits (DeLone & McLean, 2003; Petter et al., 2008). Each of the hypothesis is justified below.

Hypothesis 5a: Use has a significant positive effect on user satisfaction

Studies on the relationship between system usage and user satisfaction have often been mixed, inconclusive and at times at misleading (Bokhari, 2005; Petter et al., 2008). Bokhari (2005) in understanding this relationship using meta-analysis concluded that there exists a significant positive relationship between system use and user satisfaction. Also, Halawi et al. (2008) also found a significant positive relationship between intention to use and user satisfaction in knowledge management systems success. However, in an empirical test of IS success model with use of electronic services in a university environment, Khudhair (2016) found out that this relationship was not supported. There still is a lack of research surrounding this relationship, and accordingly, there is a consensus in the literature that more research must be done to understand the relationship (Petter et al., 2008).

It is important that this relationship is investigated in the water sector with regards to WMIS. This will deepen our understanding of the relationship in this context and more importantly add on to the IS literature.

Hypothesis 5b & 5c: Use has a significant positive effect of WMIS use for WDM and WMIS use for WM

Net benefits as established and justified in **Section 4.3.1** in this study are WMIS use for WDM and WMIS use for WM. In the IS literature, there has been a reported moderate support for the user–net benefits relationship. Wang and Liao (2006) found system to have the strongest direct and total effect on perceived net benefit in their model that assessed e-government systems success. Further Lee and Yu

(2012) on project management information systems (PMIS) produced some interesting results on this relationship. Khudhair's study, which is mentioned in the previous hypothesis, rather found a significant positive effect of use on net benefits (Khudhair, 2016). Again, the intention of PMIS use had the strongest total effect on the net benefits which in this study were the organisation's effective construction management impact and efficient construction management impact. Other studies have shown the relationship is not supported. IIvari (2005) did not find a positive relationship, and similarly, Wu and Wang's study on KMS did not support this relationship however they found the converse to be true (Wu & Wang, 2006).

Another area of importance to this study is the effect of use on water resources management decision making. The literature presented in the earlier sections have thoroughly discussed that. Generally, part of the objectives of implementing an information system in an organisation is to provide stakeholders and respective managers the appropriate information for good decision making (Olumoye, 2013). There is little to no evidence this relationship being discussed with systems which are not decision support systems (DSS). Part of the purpose of the implementation WMIS is to aid in the decision-making process.

Based on the discussion above, this hypothesis is included in the study to understand the relationship within the context further. The relationship has never been studied in this context, and it will bring a new perspective to the IS success studies at the organisational level.

4.5.1.5 H_{4a}, H_{6a}, H_{6b}: *User Satisfaction has a significant positive effect on Use, WMIS for WDM and WMIS for WMO*

The relationship that exists between user satisfaction and system use and between user satisfaction and net benefits has been given considerable attention in the literature (Iivari, 2005; Kulkarni et al., 2006; Petter et al., 2008).

The discussion below justifies each of the hypothesis that will be stated.

Hypothesis 4a: User satisfaction has a significant positive effect on use

The study of the effect of user satisfaction on use is quite common in the literature. There is the suggestion that evidence of outcomes has been moderate at the individual level, and the organisational level there is limited level to back the relationship (Iivari, 2005; Petter et al., 2008). Wu and Wang (2006) found a significant positive effect of user satisfaction on system use in a study of KMS. Yu's study on PMIS also found that the relationship between user satisfaction and intention of PMIS use was also significant and hence supported. Hou (2012) also examined this relationship and individual performance based on business intelligence systems in the Taiwanese electronics industry and found that the relationship was supported.

In the organisational context, a study of IT implementation success within SMEs in a developing country context showed a significant positive relationship exists between user satisfaction and use (Ghobakhloo, Arias-Aranda, & Benitez-Amado, 2011).

Again, no study has been conducted on how user affects the water sector, and this study seeks to understand this relationship in this context.

Hypothesis 6a & 6b: User satisfaction has a significant positive effect on WMIS user for WDM and WMIS Use for WMO

User satisfaction and its effect on net benefits have been extensively discussed in the IS literature with very strong support for the relationship(Halawi et al., 2008; Iivari, 2005; Petter et al., 2008; Rai et al., 2002). Petter and McLean (2009) found a significant positive relationship between user satisfaction and net benefits at the individual level of use when they performed a meta-analytic assessment of the DeLone and McLean IS success model. Vlahos, Ferrat and Knoepfle (2004) on the other hand reported in their research on the use of a decision making computer-based information systems (CBIS) by German managers that there was a significant correlation between user satisfaction and value of the CBIS. This value they outline covered decisions and other work responsibilities. Again at the organisational level, Ghobakhloo et al. (2011) again found a positive relationship between user satisfaction and organisational impacts in their study. The organisational impacts are considered the net benefits of the study as described earlier. Similarly, Yu's study on PMIS in construction supported the relationship with their net benefits being the impact of efficient and effective construction management respectively. Caniëls and Bakens (2012) found a similar result with PMIS on decision making quality in a multi-project environment.

As can be seen, there is extensive evidence from diverse sectors of the effect of user satisfaction on net benefits. Net benefits have in these cases presented been about effective and efficient management, decision making and the quality of the decision making and others.

The study has highlighted the importance of decision making in water resources management and this hypothesis seeks to understand the role of user satisfaction of the WMIS has on water resources decision-making. There have not been any previous studies within both the IS and WM literature that has investigated WMIS user satisfaction effect on net benefits. It is argued that the hypotheses stated hold true. This study will thus investigate the user satisfaction – net benefits perspective through the effect it has on WMIS Use for WDM and WM.

4.5.2 Organisational factors

The organisation dimension as described in Section 3.6 consists of three constructs; Leadership, Structure and Environment. The model as presented in Figure 4-1, established a set of hypotheses between these constructs and other constructs in the model. Specifically, there is a relationship between the organisation constructs and net benefits as well as WMIS Information Quality. Each of the relationships is justified below.

4.5.2.1 H_{7a} ,H_{7b} , H_{7c} ,H_{7d} , H_{7e}: Leadership has a significant positive effect on Use, User Satisfaction, Structure, WMIS for WDM and WMIS for WMO

The role of leadership to the success of WMIS use for efficient management of water resources, in general, has been discussed in Section 4.4.2.1. In the section that follows, the study justifies each of the hypotheses of the effect of leadership on the organisational structure and the net benefits the organisation derives from the use of WMIS.

Hypothesis 7a & 7b: Leadership has a significant positive effect on Use and User Satisfaction

In Section 3.5, two leadership styles from leadership theory were presented. The type of leadership practised could influence how the WMIS is used and how satisfied the users will be. For instance, the way leaders ensure that system challenges are resolved will affect the use and how they feel about system challenges. The findings from the Schepers, Wetzels and Ryter (2005) study showed a positive effect on leadership, specifically transformational leadership, and perceived usefulness which has a strong positive effect on usage. This was one of the outcomes of their research on leadership styles affect the acceptance of a technology within a globally operating high-technology Dutch company. Cho, Park and Michel (2011) in their study of how leadership affects information systems success found that transformational leadership had a significant positive effect on user satisfaction which from our earlier justification has a positive effect on the use of the information system. Leadership, mainly transformational and transactional style leadership, as seen affects either directly or indirectly through other constructs on system or technology usage. This study does hypothesise that leadership will have a significant positive effect on Use and User Satisfaction of the WMIS.

Hypothesis 7c: Leadership has a significant positive effect on Organisational Structure

Structure is a very important part of any organisation, and the styles and conditions surrounding leadership are known to affect the structure of an organisation (Meyer, 1975; Tolbert & Hall, 2016). According to Varzaru and Varzaru (2013), organisational theory shows some relationships existing between style of leadership and some types of structures within an organisation.

Grigg (2011) state that leadership is required to help water management institutions overcome barriers. This study will investigate the effect leadership has on the water management organisation structure.

Hypothesis 7d: Leadership has a significant positive effect on WMIS for WDM and WMIS for WMO

There is no doubt the role leadership or top-management, as observed from the IS literature, affects IS success (A. Sanchez et al., 2004). In the water sector, leadership and top management have to ensure the generation of credible, trusted, understandable, timely and shared information in an already challenged multi-stakeholder environment (Dent, 2010, p. 226). The outcomes of WMIS for Operations and Decision-Making thus depend on how effective leaders are in ensuring that such processes and undertaken properly.

The above hypotheses are added to the study to understand the effect of leadership on WMIS for water management operations and WMIS for water management decision-making

4.5.2.2 H_{8a}, H_{8b}: Structure has a significant positive effect on WMIS for WMO and WMIS for WDM

The set of hypotheses presented in this section justifies the effect of Structure on the net benefits or outcomes – WMIS for WDM and WMIS for WMO – of the WMIS in the study.

Hypothesis 8a & 8b: Structure has a significant positive effect on WMIS Use for WDM and WMIS Use for WMO

Structure as described in **Section 4.4.2.2** influences the water management processes. There are set organisational goals, vision and strategies that define any organisational structure. These affect the use of the WMIS in the achievement of the set goals, vision and strategies within the water management organisations.

The importance of using the current WMIS within the water management organisation structures to achieve the required benefits cannot be underestimated. The above hypotheses are thus included in this study to understand these two relationships in the water management organisation context.

4.5.2.3 H_{9a}, H_{9b}, H_{9c}: *Environment has a significant positive effect Structure, WMIS for WDM and WMIS for WMO*

The organisation's environment and particularly the water management environment has thoroughly treated in Section 3.6.2. The essence of these relationships is to understand the effect it has on the stated constructs.

Hypothesis 9a: Environment has a significant positive effect on Structure

The environment of the water management organisations, as discussed in Section 3.6.2, are inform some of the goals and visions outlined by the organisation and how certain operations are carried out. The purpose of this relationship is therefore to understand how the water management environment affects its structure.

Hypothesis 9b & 9c: Environment has a significant positive effect on WMIS for WDM and WMIS for WMO

As discussed in Section 4.4.2.3, an organisations environment influences the net benefits. Evidence suggests that environment has a significant positive effect on net benefits. The study by Erlirianto et al. (2015), mention earlier, supported this relationship.

Within the IS and water management literature, there is no evidence of this relationship or studies that shed light on this relationship. The study will thus provide an understanding of the effect of environment on WMIS for water management operations and WMIS for water management decision-making.

4.6 SUMMARY

This chapter discussed the development of the WMIS success model. The justification for the selection of the bases models and constructs forming the model was thoroughly discussed.

Following on from that, operationalisation of each of the constructs are discussed in the context of water management organisations. A total of ten constructs formed the developed model. For the system factors, the model had five constructs or dimension, namely, WMIS System Quality, WMIS Information Quality and Service Quality, System Use and User Satisfaction. The organisational factors consisted of three constructs or dimensions, namely, Leadership, Structure and Environment. The Leadership dimension was entirely new to the study. The base models did not have Leadership as a dimension but rather part of the Structure. Motivation is provided in Section 3.5. The net benefits or success outcomes for the model were WMIS for Water Management Operations and WMIS for Water Management Decision-Making. These two were also new to the study, and justification was provided in both Sections 2.6.3.1, 2.6.3.2, 4.3.1.1, and 4.3.1.2.

Finally, the conceptual model and a set of hypotheses to be tested and validated were presented. The three dimensions under technology had a total of nine hypotheses (H_{1a} – H_{3c}), human aspect had a total of six hypotheses (H_{4a} – H_{6b}), and organisation had ten hypotheses (H_{7a} – H_{9c}).

5 RESEARCH METHODOLOGY

This chapter discusses and justifies the approach taken in meeting the research goals. The chapter begins with a discussion on the role of theory in this research. I then proceed to discuss the research philosophy and provide justification for the choice of a positivist philosophical stance. Further, the research strategy that was employed, operationalisation of the constructs, the research instrument that was developed, data collection methods and the approach taken to analyse the data obtained are discussed.

5.1 ROLE OF THEORY IN THIS RESEARCH

Contribution to the field of information systems is of a theoretical nature (Burton-Jones, Mclean, & Monod, 2011; Gregor, 2002). The definition of the term "*Theory*" is not a clear one and difficult one to define (Burton-Jones et al., 2011; Gregor, 2002). Gregor (2006), however, uses the term theory in the broader IS sense to encompasses models, conjectures, frameworks or a body of knowledge. Though theories can be constructed for various reason and from different epistemological persuasions, at least two elements must be present; concepts and relationships among the concepts (Burton-Jones et al., 2011). In general, Gregor (2006) classifies IS theory based on four primary goals; Analysis and Description, Explanation, Prediction and Prescription. Accordingly, five kinds of theories – Analysis, Explanation, Prediction, Explanation and Prediction (EP), and Design and Action – are obtained based on a combination of these primary goals.

Table 5-1: Taxonomy of IS Theory Types (Gregor, 2006)

Type		Description
I.	Analysis	Says What is. The theory only analysis and describes. Causal relationships among phenomena are not specified, and predictions are not made. Example
II.	Explanation	Says what is, how, why, when, and where. The only explains without the aim to precisely predict and there are no propositions that are testable.
III.	Prediction	Says what is and what will be. There is a provision of predictions and the availability of testable propositions. However, there are no well-developed justifiable causal explanations.
IV.	Explanation and Prediction (EP)	Says what is, how, why, when, where, and what will be. Provides predictions and there is an existence of both propositions that are testable and causal explanations.
V.	Design and Action	Says how to do something. Explicit prescription for the construction of an artefact is given. Examples of such prescriptions are techniques, methods, and principles of form and function.

In this regard, the purpose of this study is to develop a model based on system and organisational factors in water management organisations that determine the success of WMIS. In Chapter 1, the research question posed was "What system and organisational factors can be used to develop a model for WMIS success that supports efficient water resources management." Subsequently, specific research questions were asked to answer the research question posed. Studies of this kind are confirmatory, and it seeks to test formulated hypotheses through empirical observation (AlKhatib, 2013).

A set of constructs – system and organisational – that explain WMIS success based on the IWRM approach to water management, relationships between these constructs, and hypotheses for the model have already been formulated. The model is tested and validated based empirical evidence from the water management context. Hence, based on the taxonomy of Gregor the contribution of this research to information systems theory is of Type IV - Explanation and Prediction (EP).

5.2 RESEARCH PHILOSOPHY

In all of research, there are underlying assumptions about the phenomenon being researched, the appropriate research methods employed for the gathering of the data, how the data will be analysed and inferences made (Myers, 1997). Knowledge about of underlying assumptions drives the research and is critical to the overall inquiry. Three philosophical stances are often discussed in the IS literature; positivism, interpretivism and critical (W. Chen & Hirschheim, 2004; Hirschheim, 1992; Myers, 1997). In this study, a positivist philosophical stance is taken. The section that follows immediately, briefly discusses the positivist research approach and justify this choice.

5.2.1 Positivists Research Approach

Positivists are of the belief that the existence of reality or object of inquiry is independent of the researcher or observer, and that scientific knowledge is objective and consists of facts only (Alavi & Carlson, 1992; Orlikowski & Baroudi, 1991; Shanks, 2002). The researcher, believed to be an impartial observer, can evaluate processes or actions in an effective and efficient objective manner (Orlikowski & Baroudi, 1991; Walsham, 1995). Regarding the nature of knowledge in positivism, knowledge consists of hypotheses that can be verified and accepted as facts. In essence, positivists take a hypothetic-deductive approach to testing theories (W. Chen & Hirschheim, 2004; Guba & Lincoln, 1994). Causal relationships are presented with an expected strong relationship between explanation, prediction, and control (W. Chen & Hirschheim, 2004).

In organisational research and IS for that matter, the positivist approach has been taken in many studies (Dubé & Paré, 2003; Shanks, 2002; Straub, Boudreau, & Gefen, 2004). According to Lee (1991), this approach which is a practical view of science to organisational research has roots in what is known as logical positivism or logical empiricism. Logical empiricism is dominant within the natural and physical sciences. Lee further contends that applying methods of the natural sciences based on positivists leanings makes social science research in general, including organisational research, avail itself to the explanatory, predictive and control power of the natural sciences.

Notwithstanding the strengths of positivism and its acceptance and dominance in IS research, there have been criticisms about its restrictiveness and limitations particularly in studies regarding organisations. (Alavi & Carlson, 1992; Chua, 1986; Myers & Liu, 2009). In making up for the existence of these limitations, criteria for rigour, validity and replicability have been enforced to enhance the quality of empirical research (Orlikowski & Baroudi, 1991).

This research as seen in Section 1.2, is aimed at developing a model to evaluate WMIS success in the water sector. To arrive at this aim, the study identifies a set of constructs that appropriately represent the WMIS in use within the water management sector and water management organisations, establish causal relationships and through hypotheses, and test them using statistical analysis. The constructs and concepts have been operationalised to be measured. It is then evident that the approach to the study aligns with positivism. Also, as an observer, I am independent of the research and collection of data is only done through a survey questionnaire.

Given the explanation provided above, a positivist philosophical approach is desirable. More importantly, the positivist approaches to operationalisation and validation – construct validity, reliability and statistical conclusion validity – techniques and guidelines, are appropriate for this research (Straub et al., 2004). Currently there are no studies on WMIS success, however, a valuable insight from the IS literature is the fact that many of the studies that developed and tested IS success models have been positivists in nature (Alshibly, 2014; Ojo, 2017; Pérez-Mira, 2010; Roky & Al Meriouh, 2015; Wang & Liao, 2006; Wu & Wang, 2006).

5.3 RESEARCH STRATEGY

The research strategy is the means by which a researcher answers the research questions in a study (Blaikie, 2000). Blaikie (2000) outlined four research strategies: inductive, deductive, retroductive and abductive. According to the author, each of these approaches is associated with the research question in the study and approach to design and research philosophy. Two of these approaches – inductive and deductive – are often discussed in the literature.

The inductive approach entails the collection of data and derivation of a generalizable concept through the use of inductive logic. Here, the researcher reflects on ideas from other works and through discourse with individuals who are knowledgeable about the research topic. Researchers then apply their intellectual abilities to construct new knowledge (also theories) on the phenomenon (Gray, 2013). It aims to explain the characteristics of individuals or people in a social setting to uncover patterns and regularities of existing relationships between them. Inductive studies are often associated with qualitative research (Blaikie, 2000;

Mouton, 1996; Myers & David, 2002). A deductive approach to research is concerned with the testing or confirmation of the hypothesis. The hypotheses usually are claims about a set of concepts that needs an explanation of the existing relationship between them (Myers & David, 2002). The concepts are abstract ideas that make up these theories and hypotheses. These concepts are then operationalised through some indicators. These are measure through data collection in the form of research survey instrument, compare that data with the theory, examine the outcomes by rejecting or accepting the hypotheses and if necessary modify the theory (AlKhatib, 2013; Gray, 2009). Deductive studies mostly use quantitative methods and align with the positivist ontology (Becker & Niehaves, 2007; W. Chen & Hirschheim, 2004). Positivists approach to research in a deductive manner to discover unilateral, causal relationships which form the basis for generalizable knowledge. Also, the beliefs of positivists about the relationship between theory and practice are mainly technical (Myers & David, 2002).

Based on the discussion, the research strategy is deductive, as a conceptual model for WMIS success with a set of hypotheses, has been developed in Chapter 4. The conceptual model is based on a theoretical background in water resources management presented in Chapter 2 and on previous IS models presented in Chapter 3.

5.4 RESEARCH DESIGN

Research design provides the blueprint of how research is undertaken. The aim is to provide an overall structure of the procedures followed by the researcher, the data collected and the means of data collection, and how the data is analysed (Leedy & Ormrod, 2013; Mouton, 1996).

The research question posed in any study drives the type of research design and appropriate methods to be used. The methods subsequently has a direct bearing on the data requirements and the way the data is analysed and interpreted (Leedy & Ormrod, 2013). Knowledge production is dependent on and inherently tied to the data collection techniques, the analysis and interpretation of this data, and by how it is achieved (Pinsonneault & Kraemer, 1993).

The positivist approach offers several methods by which data can be collected, analysed and interpreted. Mingers (2003) and Galliers (1991) provide a classification of methods common to the positivist research philosophy as shown in Table 5-2.

Table 5-2: Research method classification according to Galliers (1991) and Mingers (2003)

Galliers (1991)	**Mingers (2003)**
Laboratory Experiments	Observation, measurement and statistical analysis
Survey	Survey, questionnaire, or instrument
Field Experiments	Experiment
Simulation	Simulation
Case Studies	Case Study
Theorem Proof Forecasting	

Each of the methods listed in Table 5-2 has distinguishable features which make them suitable for a particular IS research (Galliers, 1991; Mingers, 2003).

Within IS research, surveys are one of the most widely adopted means of data collection (Pinsonneault & Kraemer, 1993). The IS literature, and social sciences research, in general, make a distinction between surveys, questionnaires or instruments and survey research. Albeit, a survey is often loosely used to refer to survey research in the literature. Surveys encapsulate all types of data collection on the characteristics, practices, actions and views about a population – organisations, groups or individuals – at some specific period (Gable, 1994; Mingers, 2003; Pinsonneault & Kraemer, 1993). It is considered the most widely used approach in IS research (W. Chen & Hirschheim, 2004).

Pinsonneault & Kraemer (1993) make this distinction clear by providing a set of characteristics that make up a survey. They posit that surveys conducted for research have three distinguishable features. The first characteristic is the purpose of the survey, which is to produce quantitative descriptions of certain aspects of the population being studied. The analysis of the survey is to fundamentally understand existing relationships between a set of variables or forecasting about the said population. It is a quantitative method that involves standardised information about the phenomenon under study. It could be about organisations, groups, individuals, applications, projects or systems. Survey research is robust and provides the means of statistically analysing data, and testing various theories and hypothesised relationships. The second characteristic is the means of data collection. Data collection is often done in a structured and systematic way through some questions which are predefined. The response data from surveys often concern the individuals themselves or some other unit of analysis. Finally, the data collected represents a sample from the population and is often statistically sufficient to allow for simple or complex analysis using statistical tools.

Once these characteristics have been identified, the quality of the research survey is affected by three other aspects– research design, sampling procedure and data collection method. The research design involves the design of the survey and is often described as either cross-sectional or longitudinal. Whether a study is cross-sectional or longitudinal depends on the time dimension involved in the survey and a strong relation with the research question being addressed. If the researcher aims to describe a specific population or test some difference within the population at some given point in time, the cross-sectional approach is suitable. Here, the findings can be safely generalised. However, if there is the need to address a research question or a phenomenon which involves change over time and to understand the origins and the outcomes associated with the phenomenon, a longitudinal approach is appropriate. With a longitudinal study, the underlying principle is the study of a phenomenon at different points in time to determine its effectiveness. Longitudinal designs have an advantage over cross-sectional designs regarding depth and seeking understanding (Pinsonneault & Kraemer, 1993). Cross-sectional studies employ survey research approach, and this many of the research that takes this approach do so due to the time constraints and resources availability (Gray, 2013).

The present study was undertaken within a limited timeframe to understand WMIS success. A positivist, quantitative, cross-sectional and survey approach is thus appropriate and is taken for this study.

5.5 RESEARCH INSTRUMENT

Survey instruments form an essential aspect of positivist research and are among the most popular means of data collection in information systems research (Newsted, Huff, & Munro, 1998). Newsted et al. (1998) state that they are useful due to a number of reasons, some of which are; easy to administer and simple to score and code, allow researchers to determine values and relationships among variables and constructs, provides generalizable responses, provides an objective way of comparing responses within different groups, times, and places, and they permit the testing of theoretical propositions in an objective manner.

A well-developed instrument brings clarity to the research question's formulation and interpretation (Straub, 1989). Given the research model thoroughly discussed in 4, the aim is to develop and validate a research instrument that translates the constructs into meaningful measures. Validation of IS survey instruments has been acknowledged as a critical part of the IS discipline (Lewis et al., 2005; Straub, 1989).

In any research, the quality of the measuring instrument used is dependent on the reliability and validity of the measures (Kimberlin & Winterstein, 2008). In this regard, the literature provides research on the development of instruments and validation (Boudreau et al., 2001; Churchil Jr., 1979; Lewis et al., 2005; Straub, 1989).

Survey instrument development and validation go through different stages or phases. The IS and social sciences literature, in general, shows a common theme in the phases or stages of research instrument development and validation (Churchil Jr., 1979; Lewis et al., 2005; Straub, 1989). Figure 5-1 above shows the phases instrument development goes through. Each of the phases contributes to the overall quality of the survey instrument and the research purpose.

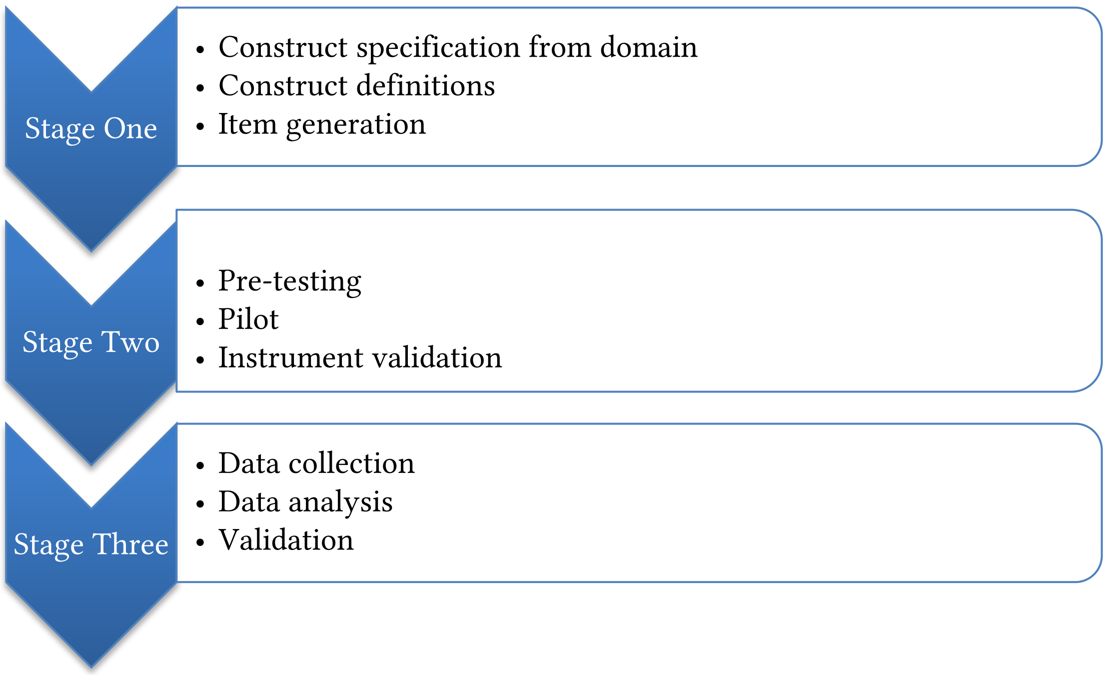

Figure 5-1: Phases of the development of the research instrument, validation and data collection

I will elaborate on each of the stages in Figure 5-1 about the constructs that form the conceptual model introduced in the previous chapter.

5.5.1 Construct Specification and Item Generation

During stage one as shown in Figure 5-1, the research explores the landscape or domain of interest to identify the constructs and various concepts that address the research questions and fit the research models in the study (Lewis et al., 2005). To determine the domain of the constructs and their respective measures, a thorough appraisal of the IS and water management literature relating to water management information systems was performed. There was an overwhelming availability of constructs measures particularly for systems quality, information quality, service quality, system use, user satisfaction, structure, environment, and leadership. The aforementioned constructs have been well-defined, utilised and validated in numerous studies (Bouranta, Chitiris, & Paravantis, 2009; DeLone & McLean, 2003; Doll & Torkzadeh, 1998; Gable et al., 2003; Gichoya, 2005; Jiang et al., 2012; Pérez-Mira, 2010; Petter et al., 2008; Seddon & Kiew, 1996; Yusof, Kuljis, et al., 2008).

Table 5-3: Constructs and sample measures for technology component

Component	Construct	Measures	References
System	System Quality	• Ease of use • Easy to learn • Response time • Useful features • Secure • Reliable • Efficient • License	(DeLone & McLean, 2003; Gable et al., 2008; Gorla et al., 2010; Halawi et al., 2008; Kulkarni et
	Information Quality	• Accurate • Standards • Reliable • Consistent	

		• Timeliness • Traceable • Secure • Complete • Accessible • Important	al., 2006; Pérez-Mira, 2010; Petter et al., 2008; Souza et al., 2009; Wu & Wang, 2006; Yusof, Kuljis, et al., 2008; Yusof & Yusuff, 2013)
	Service Quality	• Dependability • Empathy • Responsiveness • Assurance • Technical support	
	System Use	• Nature of use • Training • Motivation to use • Purpose of use • Expectations • Knowledge/expertise	DeLone & McLean, 2003; Gable et al., 2008; Halawi et al., 2008; Kulkarni et al., 2006; Pérez-Mira, 2010; Petter et al., 2008; Wu & Wang, 2006; Yusof, Kuljis, et al., 2008; Yusof & Yusuff, 2013)
	User Satisfaction	• Software satisfaction • Enjoyment • Perceived usefulness • Satisfaction with functionality • Overall satisfaction	

For the system component, Table 5-3 provides sample measures for each of the construct dimensions from the literature. The measures for each of the five construct dimensions – system quality, information quality, service quality, system use, and user satisfaction – provided are validated and used extensively in the information systems literature.

Similarly, Table 5-4 provide measures from the literature for the organisation component respectively. The measures presented for the respective components which were adopted and used as has been the norm with studies in the IS and the water resources management domains. The definitions of the constructs in the context of this research are provided in Table 5-6.

Table 5-4: Constructs and sample measures for organisation component

Component	Construct	Measures	References
Organisation	Structure	• Culture • Management • Strategy • Processes • Communication • Teamwork • Nature • Planning	(Abdullaev & Mollinga, 2010; Abdullaev & Rakhmatullaev, 2014; Erlirianto et al., 2015; Harris et al., 2001; Lucas Jr. & Olson, 1994; Mirmasoudi et al., 2012; Rivett et al., 2013; Yusof, Kuljis, et al., 2008)
	Environment	• Financing • Competition • Relationship • External effects • Politics	
	Leadership	• Empathy • Management approach • Support • Encouragement • Perception • Performance of duty	(Avolio et al., 2009; S. Chen, 2006; Cho & Michel, 2011; Dent, 2010; Dussault et al., 2013; Grigg, 2011; Kaushal, 2011; O'Reilly, Caldwell, Chatman, Lapiz, & Self, 2010; Pollard & du Toit, 2011; A. Sanchez et al., 2004)

The modification to this model is the inclusion of a leadership construct and the *WMIS for Water Management Operations* and *WMIS for Water Management Decision Making* constructs.

Table 5-5: Constructs and sample measures for net benefits

Construct	Measures	References
WMIS for WDM	• Quality of decision-making • Reduction of decision-making time • Enhancement of policy, legislation and regulation • Knowledge products • Outcomes – water quality, water demand, infrastructure planning	(Abdullaev & Mollinga, 2010; Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Curry et al., 2014; DWA, 2013; Giupponi & Sgobbi, 2013; Harris et al., 2001; Rivett et al., 2013; Rossouw et al., 2005; RSA, 1998a; Souza et al., 2009; Yusof, Kuljis, et al., 2008)
WMIS for WMO	• Operational duties and processes • Administration • Infrastructure planning • Enhancing transparency • Enhancing integrated water management • Information heterogeneity	

Again, an extensive search of the water resources management literature provided the needed constructs and relevant definitions (Abdullaev & Mollinga, 2010; Abdullaev & Rakhmatullaev, 2014; Badjana et al., 2015; Baisch, 2009; Bourblanc & Blanchon, 2014; Curry et al., 2014; Dent, 2010; Messervey et al., 2015; Mongi et al., 2016; Siebrits, Winter, & Jacobs, 2014; Souza et al., 2009; Wegelin & Jacobs, 2012). An explanation of the constructs and elaborate justification is provided in Section 4.3.1. In line with quantitative research tenets, the constructs have to be operationalised. Table 5-6 provides the definitions of the constructs from the domain how it has subsequently been operationalised for this study.

Table 5-6: Construct definition from literature and operational definition used in this study

Construct	Definition	Operational Definition
System Quality	A measure of "the desirable characteristics of the information system." (Petter et al., 2008, p. 238)	The quality of the desirable characteristics and functionality of the WMIS.
Information Quality	A measure of "the desirable characteristics of the system outputs; that is, management reports and web reports." (Petter et al., 2008, p. 239)	The quality of the desirable characteristics of the information obtained from the WMIS
Service Quality	"The quality of the support that system users receive from the IS department and IT support personnel." (Petter et al., 2008, p. 239)	The perception of the WMIS users on the quality of support received from both internal IS department and external consultants who provide IT services to the department
User Satisfaction	"Users' level of satisfaction with reports, Web sites, and support services." (Petter et al., 2008, p. 239)	The satisfaction level users in relation to the duties, available functionalities and overall usefulness
System Use	"The degree and manner in which staff and customers utilise the capabilities of an information system." (Petter et al., 2008, p. 239)	The degree in which users utilise the WMIS capabilities, the expectations and ability to use.
Structure	"Consists of (1) a set of goals to be achieved, (2) a set of tasks performed (or "processed") in order to achieve the goals, (3) a set of actors (or "processors")	The user's perception of how well organisation structure facilitates the use of the WMIS for tasks and processes.

	who process the tasks, (4) an assignment of (or method of assigning) tasks to actors, and (5) a way of communicating information between actors, which we will call messages" (Malone, 1986, p. 6)	
Environment	"The totality of physical and social factors that are taken directly into consideration in the decision-making behaviour of individuals in the organisation." (Duncan, 1972, p. 314)	The degree in which users perceive internal and external elements and the perceived desirable service qualities influence on WMIS use.
Leadership	Perception of "the leader's ability to mobilise followers towards a particular goal." (Ke & Wei, 2008, p. 210)	Satisfaction of the perception of support provided by the leadership, ability to mobilise and their understanding of the WMIS.
WMIS for Water Management Operations	The degree or extent to which information systems are used for "everyday operations" "efficient water management" (Abdullaev & Rakhmatullaev, 2014)	The degree to which the WMIS use supports daily water management operations for efficient water management.
WMIS for Water Management Decision Making	The degree or extent to which information systems are used "improve decision-making processes" of "water management organisations for sustainable and efficient water management" (Abdullaev & Rakhmatullaev, 2014)	The degree to which the WMIS supports decision-making at all levels of water management and how the information enhances knowledge products, policy, and legislation.

This serves the purpose of providing a context for this research. The second stage which is the construction of the questionnaire and subsequently improving it for the final phase goes through a few critical steps as seen in Figure 5-1. The constructs from the first phase were converted to appropriate instrument items and measurement scale for the chosen unit of analysis. The discussion on the items and scale choice follows in Sections 5.5.2 and 5.5.3 respectively. The pre-testing stage is also discussed. The pre-test provides the needed feedback on aspects such as the instrument format, the content, how respondents understand the content presented, various terminology and the completion or response times.

5.5.2 Instrument Development

This section discusses how the constructs in the previous section were operationalised. The construct measures are converted into items or questions and appropriate scales chosen for the instrument.

The survey instrument was split into eleven sections; ten of the sections representing the ten construct measures in the model and one to capture the participant profile.

5.5.2.1 Participant profile (Questions 1 – 9)

This section seeks to obtain the relevant demographic as well as data related to the years of system use, their current roles and designation in the organisation, and the WMIS used for their respective duties.

5.5.2.2 WMIS System Quality (Questions 10 – 15)

The questions in this section sought the opinion of the users on the quality of the WMIS. The system quality constructs as seen in Table 5-3, some measures. Doll & Torkzadeh's (1988) work on end-user computing satisfaction and Seddon & Kiew's (1996) empirical work on the DeLone and McLean model of IS success, serve as a guide in instrument operationalisation in IS studies. Adapting the style used in their instrument, this research uses the phrase “The WMIS is…” instead of “Is the system…”. This approach was taken to put the item in the context of the current systems in use. Using the “easy to use” item, for example, the item representation becomes “The WMIS is easy to use”.

Table 5-7: Measurement items for WMIS System Quality

Construct	Measurement Item
WMIS System Quality	1. The WMIS is easy to use 2. The WMIS is easy to learn 3. The WMIS has useful functions and features for my tasks and duties 4. The WMIS is secure 5. The WMIS is efficient. 6. The response time of the WMIS is acceptable (E.g. when I try to input and retrieve data) 7. The number of WMIS licenses available affects use of the WMIS

A total of seven items representations were adapted for the construct as shown in Table 5-5.

5.5.2.3 WMIS Information Quality (Questions 16 – 20)

Water resources management is an information-driven activity, and this section sought to collect information on the opinions of the WMIS users regarding the quality of information. Again, guided by Doll & Torkzadeh’s (1988) and justification provided in Section 4.4.1.2 the items in Table 5-8 are used. Items are rephrased as "The information…" followed by the measure used.

Table 5-8: Measurement items for WMIS Information Quality

Construct	Measurement Item
WMIS Information Quality	1. The information generated from the WMIS is accurate 2. The information generated for the WMIS follow the right standards (E.g. Reports) 3. The information generated from the WMIS is reliable 4. The information from the WMIS is traceable 5. The information from the WMIS is accessible.

For a more contextual representation of the construct, the measures standards and traceability as elaborated in section 4.4.1.2 and the literature review, are used. In all, a total of five items were chosen to represent the WMIS information quality construct.

5.5.2.4 Service Quality (Questions 21 – 25)

This section requested the opinions on the quality of service and help provided within the organisation in helping address system challenges when they occur. When it comes to service quality in IS, the work by Kettinger and Lee (1994) is often referred to. Service quality has been operationalised through five dimensions – tangibility, reliability, responsiveness, assurance and empathy. It has been shown that the reliability and responsiveness rank highly among respondents (Landrum et al., 2009). A total of five items were formulated for the service quality construct.

Table 5-9: Measurement items for Service Quality

Construct	Measurement Item
Service Quality	1. The system administrator/facilitator provides the needed assistance by the time promised or communicated 2. The system administrator/facilitator is dependable in solving system problems and challenges 3. The system administrator/facilitator is sincere in handling system challenges 4. The system administrator/facilitator is always willing to help 5. The availability of the system administrator/facilitator onsite is important in addressing system challenges I encounter

From Table 5-8, questions 1,2,3 were there to assess the reliability dimension while four was for the responsiveness dimension. The last question arose to give the justification provided in section 4.4.1.3.

5.5.2.5 System Use (Questions 26 – 29)

The questions in this section were to obtain data on the use of the system for their tasks and duties. In this regard, the items for this construct is guided by the works of Goodhue and Thompson (1995) and Goodhue (1995). The items are thus contextualised to fit the existing relationship between the WMIS and tasks or duties that arise.

Table 5-10: Measurement items for System Use

Construct	Measurement Item
System Use	1. I use the WMIS for my tasks and daily duties 2. I have the required skill to use the WMIS 3. I am motivated to continue using the WMIS for my tasks and duties 4. I have the ability to use the required functions of the WMIS need for my tasks and duties

The items were formulated to address the use, ability to use relevant functions and use for the various tasks.

5.5.2.6 User Satisfaction (Questions 30 – 34)

This section requested opinions on how satisfied users were with the WMIS for the various tasks and duties. User satisfaction is one of the most researched and used constructs for IS success measure (Baroudi & Orlikowski, 1987; Doll & Torkzadeh, 1988; Ives et al., 1983; Kettinger & Lee, 1994; Petter et al., 2008; Rai et al., 2002; Yusof, Kuljis, et al., 2008).

Table 5-11: Measurement items for User Satisfaction

Construct	Measurement Item
User Satisfaction	1. The WMIS makes it easy to perform my tasks and duties 2. The WMIS is useful in helping me undertake my tasks and duties 3. I am satisfied with the functionalities available 4. The WMIS provides the needed information in a timely

	manner 5. I am satisfied with the WMIS overall

Baroudi & Orlikowski (1987) posit that the situation and purpose of the research should be a guide regarding a choice between a long, short or simple question for the measure. In this study aside the overall user satisfaction (Baroudi & Orlikowski, 1987) two other − usefulness and satisfaction with functionalities − item measures from Yusof et al. (2008) are added as shown in Table 5-10.

5.5.2.7 WMIS for Water Management Decision-Making (Questions 33–38) and WMIS for Water Management Operations (Questions 39 – 44)

As a new and relevant additions to the model, this section obtains information about the importance of WMIS to the overall water management operations and decision making. The water management literature served as a guide in identifying suitable items for measuring this construct. There are no known measures within the water management literature, and hence this was a first regarding developing the construct, and its item representation.

Particularly, the research by Abdullaev & Rakhmatullaev (2014), Badjana et al., (2015) , Rivett et al. (2013), Rossouw et al., (2005), Souza et al., (2009) and two policy documents, the National Water Resource Strategy of South Africa (DWA, 2013) and the National Water Act (NWA) of South Africa (RSA, 1998a) served as basis for identifying these item measures.

Table 5-12: Identified aspect and functions of water resources management

Aspect	Functions	References
Water Management Decision-Making	Production of reports, documents and knowledge products	Abdullaev & Rakhmatullaev (2014), Schreiner & Hassan (2010), Curry et al., DWA (2013)
	Decision on policy, legislation and regulation	Rivett et. al., (2013), Souza et al., (2009), DWA (2013), McDonnell (2008)
	Water management decision outcomes (water quality monitoring, water demand, infrastructure planning)	Rossouw et al., (2005), Rivett et al., (2013), Souza et al., (2009), Republic of South Africa (1998a)
	Improve decision making quality	Giupponi & Sgobbi (2013), Miller et al., (2004), McDonnell (2008)
Water Management Operations	Supporting operations of the water management process	Souza et al., (2009), Abdullaev & Rakhmatullaev (2014), McDonnell (2008), Arsene et al., (2012)
	Enhancing administrative duties	DWA (2013), Rivett et al., (2013)
	Transparency and inclusivity of the water management process	DWA (2013), Abdullaev & Rakhmatullaev (2014)
	Promoting integrated water management	Abdullaev & Rakhmatullaev (2014), Schreiner & Hassan (2010), McDonnell (2008), Badjana et al., (2015)
	Enhancing infrastructure planning	Badjana et al., (2015), Abdullaev & Rakhmatullaev (2014), Zeb et al., (2012)

Two main aspects and various functions of water resource management were identified from the literature sources as shown in Table 5-12.

Table 5-13: Measurement items for WMIS for Water Management Decision Making

Construct	Measurement Item
WMIS for Water Management Decision Making	1. The WMIS supports decision making regarding my work/duties 2. The WMIS information enhances production of reports, documents and other knowledge products 3. The WMIS information enhances decisions on policy, legislation and regulation (E.g. Blue/Green drop and others) 4. The WMIS aids water management decision-making outcomes (water quality, water demand, infrastructure planning etc.) 5. That quality of decision-making is improved through WMIS use 6. The WMIS has reduced the water management decision-making time

The use of WMIS and WMIS information thereof for the various aspects have been justified in sections 4.3.1.1 and 4.3.1.2. The identified aspects and functionalities provided the guide for the constructs and measurement items in Table 5-13 and Table 5-14 respectively.

Table 5-14: Measurement items for WMIS for Water Management Operations

Construct	Measurement Item
WMIS for Water Management Operations	1. The WMIS supports operational duties of the water management process (E.g. Enhancing the water quality monitoring process, water demand management, asset management and others) 2. The WMIS aids operational duties that promote integrated water management. 3. The WMIS enhances water management administrative duties. 4. The WMIS enhances transparency and inclusivity in water management process. 5. The WMIS enhances infrastructure planning 6. The WMIS aids data and information heterogeneity in water management.

WMISs, in general, are tools that support or enhances the water management process, and that is evident in how the items were formulated.

5.5.2.8 Leadership (Questions 46 – 50)

This section seeks the opinions of participants – WMIS users – on the role of leadership or management regarding their duties about WMIS use. As discussed in Section 4.4.2.1, and guided particularly by the works of Dussault et al., (2013), Avolio et al., (1999), and supported by Grigg's (2011) perspective of leadership in water resources management, the items in Table 5-15 were used.

Table 5-15: Measurement items for Leadership

Construct	Measurement Item
Leadership	1. The leadership ensures that the needed support is provided when I encounter challenges in the use of the WMIS for my duties 2. When I produce work that affects the decision-making process, my superior and management recognises and commends me 3. Management follows up regularly on the tasks I am assigned to ensure there are no errors or problems 4. Leaders have a good understanding of how the WMIS functions 5. Leaders encourage and support working together, including asking colleagues for help when the need arises

5.5.2.9 Structure (Questions 51 – 54)

The questions in this section were to obtain information on how the structure of the organisation supports the WMIS for their various duties and achievement of the overall organisational goals. This construct uses the items from the Yusof et al., (2008) with motivation from the water management literature (Abdullaev & Rakhmatullaev, 2014; Rivett et al., 2013) as shown in Table 5-16.

Table 5-16: Measurement items for Structure

Construct	Measurement Item
Structure	1. Communication between different sections/departments using the WMIS improve the tasks and processes. 2. Integration between the different section/sections improve my use of the WMIS. 3. The organisation's goals, vision and strategy are clearly defined. 4. The organisation provides the needed infrastructure for the WMIS use.

5.5.2.10 Environment (Questions 55 – 58)

This section seeks information on the participant opinions on how the organisation's environment affects the use of the WMIS. Again, the environment construct uses contextualised item measures from Yusof et al., (2008). The items are shown in Table 5-17 below.

Table 5-17: Measurement items for Environment

Construct	Measurement Item
Environment	1. Financing influences use of the WMIS (E.g. Not being able to purchase more licenses to use). 2. The outcome of the desired service quality for our clients affects how I perform my tasks. 3. I easily ask my colleagues for help, share skills and knowledge about the WMIS when the need arises.

	4. There is no competition among my colleagues regarding our duties and tasks.

5.5.3 Item Scaling

The item scale used for the research instrument forms an important part of the data quantification and the analysis. This study adopted a Likert scale to obtain responses of the participants regarding the measurement items. A 5-point scale – 1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree and 5: Strongly agree – was used for all the items measures for each of the constructs. The complete instrument is provided in Appendix A of this document.

5.5.4 Pretesting of Instrument

Pre-testing is an important process in research. It provides a means of obtaining feedback empirically from a controlled sample (Urbach & Ahlemann, 2010). A request to pre-test the developed instrument was made to the City of Cape Town Water Department. In all, ten volunteers from the scientific services section of the City of Cape Town's Water Department agreed to participate. Participants were asked to complete the instrument and make suggestions they consider important.

Indeed, the pretesting provided insights particularly on questionnaire completion time, ambiguity with the wording or readability, sentence duplication and the content. The response was invaluable for the modification of the questionnaire for piloting of the main data collection.

5.5.5 Pilot Study

Once the necessary amendments had been done to the instrument based on the responses obtained from the pretesting, the new instrument was sent out again to a new set of volunteers from the City of Cape Town's Water Department. The responses were overall positive, and there were no further suggestions made regarding the instrument.

5.5.6 Content Validity of the Instrument

The final part of the second stage is the validation of the instrument's content. Here, the aim is to quantitatively validate the items used to represent each of the constructs employed and to further eliminate items that do not meet a certain criteria (Ayre & Scally, 2014; Lewis et al., 2005).

A common approach to validating an instrument's validity, commonly seen in the literature is the use of content validity ratio (CVR) which was developed by Lawshe (1975). Since then it has been applied in many studies to validate content validity (Ayre & Scally, 2014; Lewis, Snyder, & R. Kelly, 1995). Lawshe's (1975) CVR method is a linear transformation of the proportionality of agreement on how experts in a study of interest rate a given item on the importance attached (Ayre & Scally, 2014). The CVR is given by the formula

$$CVR = \frac{n_e - (N/2)}{N/2},$$

where n_e is the number of experts specifying an item or items chosen as relevant, that is "essential" or "important", and N is the number of experts involved. The approach by Lewis et al., (1995) where the n_e above is used will be employed.

An instrument was developed after the pilot stage was completed to ascertain the content validity based on the modified Lawshe approach by Lewis et al., (1995). The items under the various constructs were given a scale ranging from 1 to 3; 1 – Not Relevant, 2 – Important (but not essential) and 3 – Essential. This is according to the CVR method employed.

Water managers in various capacities within the City of Cape Town were then requested to volunteer for completion of the instrument. A total of 20 expert volunteers in various capacities were contacted with a link to the questionnaire online. A Google form[3] was created to collect the data for this purpose. Another set of 20 questionnaires were delivered personally to two sections within the city's water departments. This was necessitated based on previous interaction that had taken place with some of the water managers, in case some decided to complete the paper questionnaires rather than the online version.

In response to the questionnaire, fifteen expert volunteers completed the online questionnaire. However, none of the paper questionnaires were returned. The fifteen represented a range of experts – information management specialist for water and sanitation, integrated planning, strategy and information management, information and technical managers and municipal water managers.

Once the data has been obtained, the CVR is computed to eliminate items that do not meet the required criteria. In this regard, Ayre & Scally (2014) in a recent study provided $CVR_{critical}$ values for panellists between 5 and 40. For a panel of fifteen,

[3] Online-based data collection platform by Google Inc.

the $CVR_{critical}$ value 0.6 as seen from the table provided in Ayre and Scally (2014). Based on this fact, each of the item measures for the instrument was computed.

Table 5-18: Content Validity Ratio for Instrument Items

CVR	*f*	CVR	*f*
0.90 − 1.00	19	0.40 − 0.49	1
0.80 − 0.89	11	0.30 − 0.39	1
0.70 − 0.79	10	0.20 − 0.29	1
0.60 − 0.69	8	0.10 − 0.19	0
0.50 − 0.59	0	0.00 − 0.09	1

Table 5-17 shows the CVR values obtained from the computation. A total of 48 out of 53 instrument items passed the required $CVR_{critical}$ value of 0.6 stated earlier. Of the five items that did not meet the $CVR_{critical}$ value, one each belonged to the *System Quality*, *Information Quality*, *Structure*, *WMIS for Water Management Decision-Making*, and WMIS *for Water Management Operations* constructs and were therefore taken out of the final instrument.

Table 5-19: Constructs and CVR values corresponding to eliminated items

Construct	Item	CVR Value
System Quality	The response time of the WMIS is acceptable (E.g. when I try to input and retrieve data)	0.467
Structure	I get rewarded for my work in the organisation	0.067
WDM	The WMIS has reduced the water management decision-making time	0,333
WMO	The WMIS use aids data and information heterogeneity	0,200

Table 5-18 shows a summary of the items eliminated, the constructs they fall under and their corresponding CVR values that informed their elimination.

5.6 DATA COLLECTION

Data collection for the study was undertaken through two means – online or web-based survey and a paper-based instrument.

The web-based survey was created and hosted on Google. The web-based approach provided advantages to its adoption. To begin with, the first aim was to avoid having paper entries around and reduce the workload of entry and errors. Google forms, which is the tool used, provides the ability to anonymise the entries which are an important part data collection. Another reason for this choice was the ability to have all entries stored in the cloud as one spreadsheet which can be downloaded and easily analysed. Finally, there was the option to force the answering of all questions before submitting. This meant participants couldn't leave any question unanswered.

The paper-based instruments were employed to provide participants who preferred this option, the means to do so.

5.6.1 Data Collection Strategy

The process of data collection for the study was done by liaising with the various designation heads. The municipal policy does not allow me to have access to staff emails and contacts, so I had to send the web address of the survey to a few senior professional officers and administrators, who then forwarded it to the staff.

5.6.2 Follow-up Procedures

Follow-up on data collection is accepted as an important means of improving response rates of respondents and improving studies (Dillman, Smyth, & Christian, 2014; Urbach & Ahlemann, 2010). Follow-ups were made with the City of Cape Town via email and phone calls. Reminders were sent every two weeks to the contacts within the municipalities, or direct phone calls were placed. It should be noted that since the researcher could not send emails directly to participants due to rules in sending bulk email to municipal workers and confidentiality surrounding email access by a non-employee, reminders were sent to research contacts responsible in the various municipalities. This approach was very helpful in getting participants who had forgotten to complete the survey to do so thereby increasing the number of participants.

5.6.3 Survey Response Rate

An important step before the model validation process is ensuring that the empirical data gathered is of high quality. The quality of data obtained has a direct impact on the research outcomes. The response rate from the data collected has been stated as one of the means of assessing the quality (Lewis et al., 2005; Urbach & Ahlemann, 2010).

A total of 267 respondents completed the survey, and all of that was done online. This number was from a population of about 700 WMIS users. The response rate is then about 38%. Sivo, Saunders, Chang and Jiang (2006) in an extensive study of response rate in leading IS journals, reported a response rate of between 17 − 28% for IS research. Hence, the response rate obtained for this research is consistent with IS research.

5.7 DATA VALIDATION

During the data collection phase, the quality of the empirical data must be verified (Lewis et al., 2005; Urbach & Ahlemann, 2010). The steps taken to achieve this quality is discussed.

5.7.1 Data Accuracy

Before data analysis commences, the accuracy of the data has to be checked as part of the data validation process. Here, the data is checked for errors that might have arisen during entry. Majority of the data came from the web-based instrument – Google forms. As discussed earlier, some of the advantages of using such a cloud service are the ability to set filters and specific entry limits. This provided an inherent layer of accuracy. For the others which were paper-based, the entries were checked thoroughly and simple functions in Microsoft Excel 2016 to check for invalid entries. No invalid entries were found through the process.

The Google forms platform provided the ability to download all the forms in a Microsoft Excel/Spreadsheet (xlsx) format or a comma separated value (CSV) file format.

5.7.2 Missing Data Check

Since the instrument was developed in the cloud (Google Forms), filters and validations were set for each question. This ensured that the participants could not skip any question. Concerning the paper-based questionnaires, I discussed with the heads of the sections on the need to complete every question and section on the questionnaire. On return of the questionnaires, none of them had an incomplete section or question.

5.7.3 Outliers Verification

Verification of outliers in any empirical data is crucial in making sure the outcome and interpretation made from the analysis is meaningful. Outliners in many cases signify bad data which can be attributed to a number of things (Osborne & Overbay, 2004). Identifying and removal or keeping of outliers depend on the researcher and the interpretations thereof. Many approaches are available in the literature in assisting with outliers (Osborne & Overbay, 2004; Selst & Jolicoeur, 1994). A visual approach to outliers, using boxplots and histograms, was employed. A visual inspection of the data for each of the observed variables showed that there were no unusual entries and hence none was eliminated.

5.8 CHECKING FOR BIASES

To ensure the model developed is properly validated, Urbach and Ahlemann (2010) suggest that nonresponse bias and common method bias be assessed. The sections that follow discuss these two.

5.8.1 Nonresponse Bias

Nonresponse bias arises when a section of the survey participants who are targets for the study do not respond. Such a situation causes an unreliable representation of the sample that was selected for the study (Dillman et al., 2014; Urbach & Ahlemann, 2010). Minimising nonresponse bias is thus important. One way of assessing nonresponse bias after data collection is comparing the early respondents to those of the later respondent's responses and checking for any significant difference (Igbaria & Tan, 1997; Urbach & Ahlemann, 2010).

5.8.2 Common Method Bias

Another form of bias is the common method bias. This occurs when a significant amount of covariance shared among the variables – dependent and independent – can be attributed to the methods commonly used in the collection of the data (Ali, 2012; Urbach & Ahlemann, 2010). The Harman single-factor test is considered one of the most popular means determining common method bias (Malhotra, Kim, & Patil, 2006). This study employed the approach to ascertain common method bias. The results showed no existence of common method bias.

5.9 VALIDATION OF MODEL

Validation of instruments used in any research is an important aspect of the whole scientific process of data gathering. Instrument validation in IS has been discussed extensively in the lS literature (Straub et al., 2004).

5.9.1 Indicator (Item) Reliability

Indicator reliability is a measure of how the variance of indicators or items is explained by its corresponding construct or LV (Urbach & Ahlemann, 2010). The indicator loadings on their respective constructs or LVs serves as a measure of the indicators reliability.

5.9.2 Internal Consistency Reliability

Internal consistency reliability is a measure of the degree to which the manifest variables load simultaneously with increases in the constructs or LVs (Urbach & Ahlemann, 2010). Cronbach's α has been the choice of measure over the years. However, composite reliability (CR) has been the preferred and recommended choice particularly for the PLS approach to structural equation modelling in recent literature (Chin, 1998; Hair et al., 2011; Urbach & Ahlemann, 2010). The advantages to using composite reliability as a measure are because two reasons; indicators loadings are not assumed equal in the population and its ability to accommodate indicator reliabilities that are different. The later does so without underestimating like Cronbach's α later (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014).

5.9.3 Convergent Validity

Convergent validity is one of the ways of assessing construct validity. Items thought to reflect a particular construct have a high correlation with one another, and this is manifested through convergent validity (Straub et al., 2004). To test convergent validity, a few approaches have been employed. The Multitrait-Multimethod Matrix(MTMM) (Campbell & Fiske, 1959), Average Variance Extracted (AVE), Principal Component Analysis (PCA) and Confirmatory Factor Analysis (CFA) (Jöreskog, 1969; Straub et al., 2004) with the latter being the accepted and widely used approach in information systems.

5.9.4 Discriminant Validity

The measurement items of a construct should reflect the construct it measures and must differ from other items that are not constituents of that particular construct (Ravand & Baghaei, 2014; Straub et al., 2004). Discriminant validity provides the means of validating this measure. In establishing discriminant validity, several measures and methods have been suggested in the literature. The MTMM (Campbell & Fiske, 1959), paired constructs test (J. C. Anderson & Gerbing, 1988; Farrell, 2010), Average Variance Extracted (AVE) (Fornell & Larcker, 1981; Ravand & Baghaei, 2014), CFA (Straub et al., 2004) and the Heterotrait-monotrait (HTMT) (Jörg Henseler, Ringle, & Sarstedt, 2014) ratio of correlations are some of the approaches found in the literature.

5.10 ANALYSIS OF DATA

The approach taken to code, analyse and provide an explanation for the analysed quantitative data is described in detail in the sections that follow. As indicated earlier, a five-point Likert scale was employed in this study. Based on the model developed and presented in Chapter 4, the formulated hypotheses and the data obtained, Structural Equation Modelling (SEM) was the choice of the method employed for the analysis. The sections that follow discuss the SEM approach in detail.

5.10.1 Structural Equation Modelling

Structural equation modelling as a statistical technique is useful in testing and estimating causal relationships between multiple independent and dependent constructs (Urbach & Ahlemann, 2010). The objective of SEM is to identify a single set of parameters that minimises the total difference between the implied covariances of the model and that of the population (Chumney, 2013). Urbach and Ahlemman (2010) posit that philosophically research that employs SEM is often ascribed to positivists epistemology. SEM has gained grounds in its application in IS research and the social sciences over the years (Gefen, Straub, & Boudreau, 2000; Hair, Hult, Ringle, & Sarstedt, 2014; Urbach & Ahlemann, 2010).

There are two approaches to SEM – Covariance-based SEM (CB-SEM) approach and Partial Least (PLS) Squares SEM(PLS-SEM) or PLS Path Modelling (PM). I will discuss the differences between the two approaches briefly and finally provide a reason for my choice of using PLS for this study.

5.10.1.1 PLS-SEM AND CB-SEM

PLS-SEM and CB-SEM are two approaches used to estimate relationships in structural equation models (Hair, Hult, et al., 2014). Whereas CB-SEM estimates model parameters to maximise the discrepancy between estimated and sample covariance matrices, PLS-SEM, on the other hand, maximises the explained variance of the endogenous latent variables. The PLS-SEM achieves this by estimating partial model relationships based on an iterative sequence of ordinary least squares regression (Hair, Sarstedt, Ringle, & Mena, 2012). The PLS approach can be used in theory development and for predictions whereas CB-SEM is applied in testing or confirming theory (Hair, Hult, et al., 2014; Urbach & Ahlemann, 2010). PLS-SEM maximises the explained variance of the latent variable while CB-SEM estimates model parameters in a way that minimises the discrepancy between the estimated and sample covariance matrices (Monecke & Leisch, 2012). It takes a component-based approach to structural equation models (Urbach & Ahlemann, 2010; Vinzi, Trinchera, & Amato, 2010). CB-SEM makes strong assumptions about the distribution whereas underlying assumption about the data using PLS-SEM is relaxed (Monecke & Leisch, 2012).

Each of the stated approaches is different in the purpose of the analyses employed, basis of their statistical assumptions, and the nature of the fit statistics outcome (Gefen et al., 2000). PLS-SEM is an appropriate alternative to the established CB-SEM approach. In studies where the phenomenon is relatively new as is the case with the current study – where no assumptions are made about the distribution, the number of constructs, and many indicators involved – PLS-PM is more appropriate (Hair et al., 2011).

The justification for choosing PLS-SEM over CB-SEM is based on the characteristics of the data and the model. The sample size is one of the factors that directed the study towards this choice. As stated in the literature (Hair, Sarstedt, et al., 2014; Urbach & Ahlemann, 2010), PLS-SEM performs well with adequate sample size. In collecting data for the PLS-SEM analysis, a seven-point Likert scale was used. The PLS approach is also known to work well with non-normal interval, nominal, ordinal, and ratio scaled variables, which was used in this study (Reinartz, Haenlein, & Henseler, 2009). Lastly, this study relied on a purposive sampling technique, which aligns with the strengths of PLS-SEM (Hair, Sarstedt, et al., 2014).

In the section that follows, the theoretical foundations of PLS-PM are presented.

5.10.2 Theoretical Foundations of PLS Path Modelling

PLS path model consists of a structural model (inner model) relating to some latent variables and the measurement model (out model) that relates to manifest variables (Jörg Henseler, 2010; Vinzi, Trinchera, et al., 2010). An example of what constitutes a PLS path model is shown in Figure 5-2.

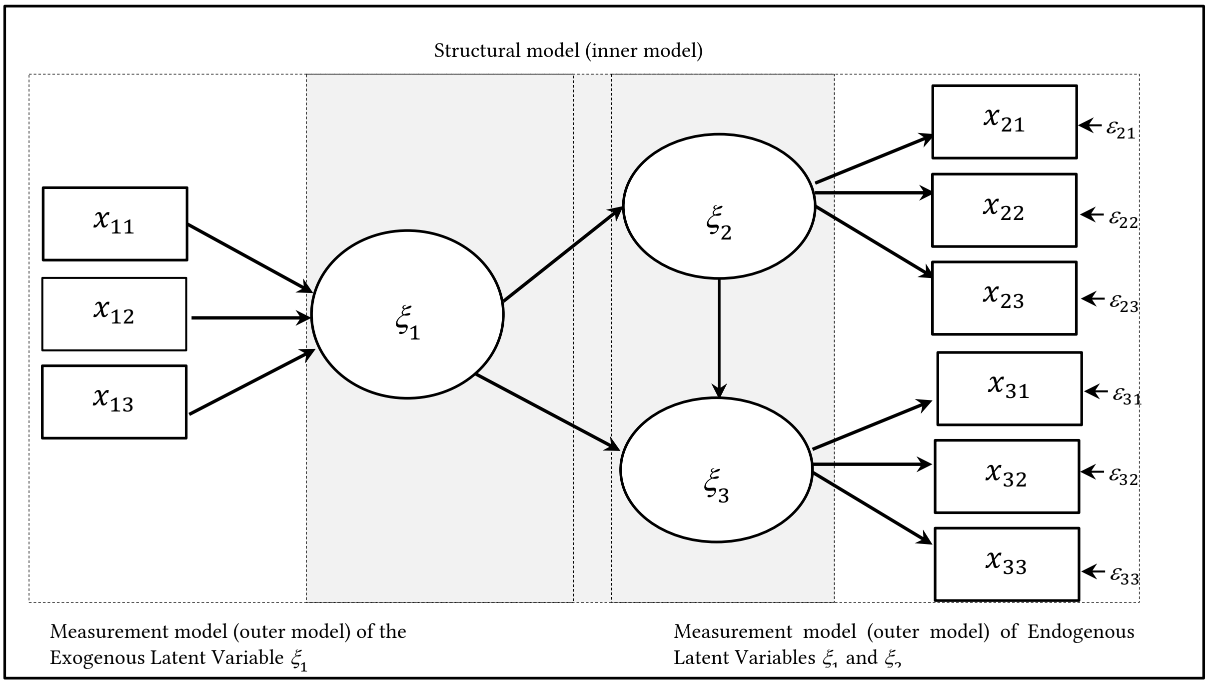

Figure 5-2: A Simple PLS Path Model (Adapted from Henseler (2010))

In Figure 5-2 above, the PLS-PM consists of an exogenous LV, ξ_1, and two endogenous LVs, ξ_2 and ξ_3. Latent variables (LVs) are variables that cannot be measured directly. These variables are often abstract, and one needs to find ways of measuring them. Some examples from the IS literature are *user satisfaction*, *usability*, *motivation* and *service quality*. LVs, take on names such as constructs, factors, composites and concepts (G. Sanchez, 2013). These are common in research and researchers often must find a way of quantifying them. Exogenous variables do not have predecessors whereas endogenous LVs do. The operationalisation of the LVs is done through a set of manifest variables (MVs) or measures or indicators, in this case, the x_i.

5.10.2.1 The Structural Model (Inner model)

A structural model or inner model consists of a set of LVs, exogenous and endogenous, related to each other. Without loss of generality, it is assumed that LVs and MVs are standardised. The relationship that exists between the LVs can be expressed mathematically as:

$$\Phi = \Phi B + Z \tag{1}$$

Where Φ represents the vector of LVs, B represents the matrix of path coefficients and Z residuals of the inner model. The inner model is assumed to be recursive for the basic PLS setup subject to predictor specification. The residual term of an endogenous LV and its predictor variables are assumed to be uncorrelated. Thus, the predictor specification reduces (1) to:

$$E(\Phi | \Phi) = \Phi B \tag{2}$$

The predictor specification assures desirable estimation properties in Ordinary Least Squares (OLS) modelling (Vinzi, Trinchera, et al., 2010).

5.10.2.2 The Measurement Model (Outer Model)

The measurement model (outer model) establishes a relationship between the block of observed (MVs) and its latent variables (LVs). Observed variables are also referred to as manifest variables or indicators in the literature (Chin, 1998). There are two measures under the measurement or outer model – reflective and formative measurement as depicted in Figure 5-3 and Figure 5-4.

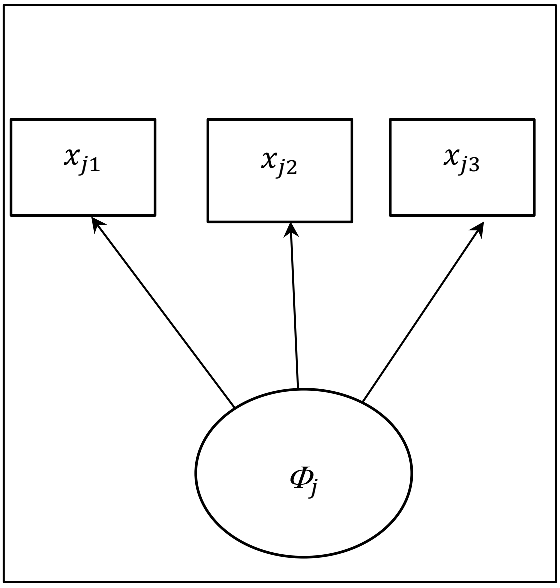

Figure 5-3: Measuring an LV, Φ_j, by of MVs, x_{j1}, x_{j2}, x_{j3} , in a reflective way

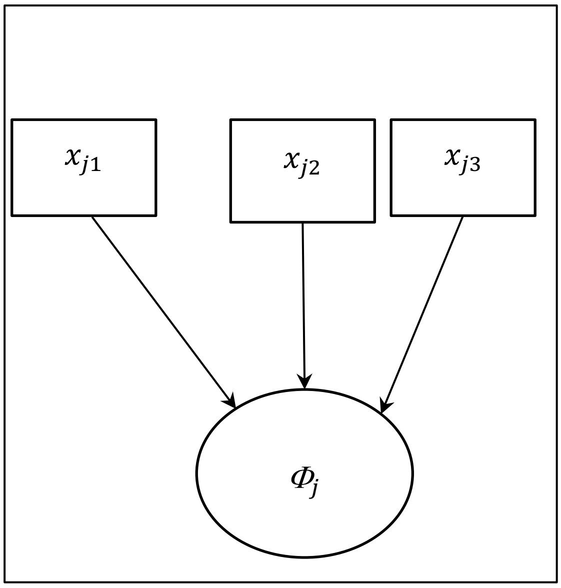

Figure 5-4: Measuring an LV, Φ_j, by of MVs, x_{j1}, x_{j2}, x_{j3} , in a formative way

The reflective way or mode is the most common type of PLS path model. This type of model assumes a causal relationship from the MVs to the corresponding LV (Jörg Henseler, 2010). The existing block of MVs reflects the corresponding LV. Like the rules established with LVs, the outer model relationships are considered linear. Each MV, x, is modelled as a linear function of the LV, ξ, and its residual ε by:

$$x = \lambda\xi + \varepsilon, \tag{3}$$

where λ is the loading coefficient. The outer residuals and the LV belonging to the same block are uncorrelated since the outer relationships are subject to predictor specification. Thus, Eqn. (3) is becomes:

$$E(x|\xi) = \lambda\xi, \tag{4}$$

With the formative way or mode, the LV is caused by the MV. Thus there is an assumption of causal relationships from the MVs to the LVs (Jörg Henseler, 2010). In simple term, MVs form the LV. The linear relationships existing for a unique block of MVs is given by:

$$\xi = X\pi + \nu \tag{5}$$

with the predictor specification reducing Eqn. (5) to become:

$$E(\xi|X) = X\pi\,, \tag{6}$$

Depending on how the LVs are measured, they assume the corresponding measure used. If all the LVs in a PLS model are measured reflectively, it is termed a reflective measurement model. Consequently, if the LVs are measured in a formative way, it is termed a formative measurement model. When both are found measures are found in a given SEM, it is termed a MIMIC or multi-block model (Tenenhaus et al., 2005).

5.10.3PLS –PM Approach

The PLS-PM approach is replete in the IS literature (Hair, Hult, et al., 2014; Jörg Henseler et al., 2014; G. Sanchez, 2013; Tenenhaus et al., 2005). The method is credited to Herman Wold's work in the 1960s (Morales, 2011; Wold, 1980). The PLS approach to SEM, also referred to as PLS-Path Modelling (PLS-PM), estimates the coefficients of the system of structural equations using PLS. The LVs are approximated by respective block of MVs or indicators (Chin, 1998). In so doing, the data distribution and size of the sample does not pose a limitation (Morales, 2011; Urbach & Ahlemann, 2010). The PLS-PM is an important technique specifically designed with the social and behavioural sciences in mind.

The PLS-PM approach, in general, provides two possibilities of its application; confirmation of theory or development of theory. In the case of theory development, the approach is used in the development of propositions by exploring relationships between variables (Urbach & Ahlemann, 2010). This makes PLS-PM a highly suitable technique to IS research since the development of theory is central. The section that follows outlines the PLS-PM algorithm.

5.10.3.1 PLS-PM Algorithm

The PLS-PM consists of a system of interdependent equations that aims to estimate the relationships between manifest variables and their corresponding latent variables (Vinzi, Chin, Henseler, & Wang, 2010). The algorithm, in essence, aims at iteratively solving blocks of the measurement model and then subsequently estimating the path coefficients in the structural model (Vinzi, Trinchera, et al., 2010). The basic PLS algorithm (Lohmöller, 1989) developed by Wold (1980, 1985) is as follows:

Stage 1:	Iterative estimation of weights and LV scores
	Starting at Step #4, repeat steps #1 to #4 until convergence
# 1	Inner weights
# 2	Inside approximations
# 3	Outer weights
	a) In a Mode A Block (Reflective) b) In a Mode B Block (Formative)
# 4	Outside approximation
Stage 2:	Estimation of path and loading coefficients
Stage 3:	Estimation of location parameters

As seen above, there are three stages involved in obtaining the weights, and the loading and path estimates subsequently. The first stage involves an iterative process to obtain a set of weights that are used to estimate the LV scores. The process is a simple or multiple regression that depends on the type of model. Stages two and three follow once the LV estimates are obtained. Here, the loadings, path coefficients, and mean scores and location parameters for the LV and MVs are obtained through an application of simple non-iterative ordinary least squares (Chin, 1998). A detailed treatment of the algorithm can be found in Henseler(2010), Tenenhaus et al., (2005), Lohmöller(1989), Chin (1998) and Wold (1980, 1985).

5.10.3.2 Software for the PLS-PM

The first developed software for PLS-PM was the LVPLS v1.6 by Lohmöller in 1984 (Lohmöller, 1989). Since then, many software has been developed to implement the PLS algorithm. Some of the common ones found in literature are SmartPLS (Ringle, Wende, & Will, 2007), XLSTAT-PLSPM[4] developed by Addinsoft and PLS-Graph (Chin, 1998). There are also packages that implement PLS-PM in the statistical package, R. SEMPLS (Monecke & Leisch, 2012) and PLSPM (G. Sanchez, 2013) are two of such packages for implemented for PLS path modelling in R.

The plspm package is run in R Studio, R version 3.3.2 (2016-10-31), on a Mac Book Pro with macOS Sierra[5] (Version 10.12.3), a 2.7 GHz Intel Core i5 processor and 8GB 1867 MHz DDR3 memory

This research adopts the plspm package in R by Gaston Sanchez (2013). The plspm package in R, according to Sanchez (2013) began as part of his PhD in 2005 with the very first version only being released in April 2009. The model developed for this research follows the same approaches used in the plspm implementation by Sanchez to fit a partial least squares path model.

5.11 PLSPM APPLIED TO THE RESEARCH

There are three mandatory aspects in the implementation of plspm model in R – a dataset, an inner model and an outer model (G. Sanchez, 2013). Each of these aspects about the model in this research will be elaborated on in the sections that follow.

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[4] https://www.xlstat.com/en/
[5] Apple Mac Operating System

5.11.1Creating the Inner Model Matrix

This matrix is the plspm software approach to representing the structural (inner) model. It can be seen as a network representation of the model or flowchart representation of the causal process (G. Sanchez, 2013). As stated earlier, this implementation is in R, and thus it uses the R environment notation. The inner model matrix is a lower triangular Boolean matrix is defined as the **`path_matrix`** within the plspm implementation.

5.11.2Creating the Outer Model Matrix

The outer model matrix is a representation of the outer (measurement) model in plspm. Here, the manifest variables that form each block are defined by a **`list`** of vectors to be used in running the model. Each element that represents the construct or LV is represented by a vector of indices in the R environment.

5.11.3Choosing an Appropriate Mode

The vector of modes represents the type of model – reflective or formative – being implemented. In the PLS modelling parlance, these two representations are often referred to as Modes A and B. In plspm, it is defined by a vector **`mode`** with as many letters as the LVs. The vector is represented by A or B for reflective and formative ways respectively.

5.12 ASSESSMENT OF THE PLS PATH MODEL

The assessment of any PLS-PM model is based on the analysis and interpretation of the measurement(outer) and structural (inner) models. The results and inferences made from this assessment helps the researcher answer the research question(s) posed, draw conclusions about existing relationships in the model and derive relevant implications for both theory and practice (Hair, Hult, et al., 2014; G. Sanchez, 2013; Urbach & Ahlemann, 2010).

5.12.1Measurement (Outer) Model Assessment

As seen from **5.10.2.2**, a measurement model can be reflective or formative. The type of model determines the assessments or evaluations to be carried out. The model developed in this study is a reflective measurement model and hence what this section will do is elaborate on evaluations relevant to this model. A reflective measurement model is assessed by way of the internal consistency (composite reliability), indicator reliability, convergent reliability (average variance explained) and the discriminant validity (Hair, Hult, et al., 2014; Lewis et al., 2005; Straub et al., 2004). The sub-sections that follow briefly discusses the approaches in which these evaluation measures are done in PLS path modelling.

5.12.1.1 Internal Consistency Reliability (Composite Reliability (CR))

Internal consistency reliability is the first criterion in the measurement model to be assessed. Traditionally, *Cronbach's* α has been used as a measure. However, limitations with this measure have prompted a different measure to be employed, the composite reliability, ρ_c (Hair, Hult, et al., 2014; Jörg Henseler, Ringle, & Sinkovics, 2009). The composite reliability is based on the loadings of the indicators (Hair, Hult, et al., 2014; Jörg Henseler et al., 2009). It is expressed by the formula:

$$\rho_c = \frac{(\sum \lambda_i)^2}{[(\sum \lambda_i)^2 + \sum_i var(\varepsilon_i)]} \ , \qquad (7)$$

Where λ_i is the outer (component) loading of an indicator or variable i of a unique LV or construct, ε_i is the error associated with variable or item i, and $var(\varepsilon_i)$ is the variance of the measurement error which is given as $1 - \lambda_i^2$. The values of $\rho_c \in$

$(0,1)$ are given a similar interpretation as *Cronbach's* α. Values of $\rho_c > 0.7$ for internal consistency reliability are accepted (Hair, Hult, et al., 2014; Jörg Henseler et al., 2009; Straub et al., 2004). In plspm, internal consistency reliability was assessed by the Dillon-Goldstein's rho value (G. Sanchez, 2013).

5.12.1.2 Indicator Reliability (Item reliability)

According to Henseler et al., (2009), the absolute outer (component) loadings should be greater than 0.70 which this study adheres to. Further, the general rule is that for indicators loadings with values between 0.40 and 0.70, the researcher should only consider removing the indicator if this leads to a CR increase above the suggested threshold value (Hair et al., 2011).

5.12.1.3 Convergent Validity (Average Variance Explained (AVE))

The average variance expected (AVE) is used as a criterion for convergent validity (Hair, Hult, et al., 2014; Jörg Henseler et al., 2009). It is represented as follows:

$$AVE = \frac{(\sum \lambda_i^2)}{[\sum \lambda_i^2 + \sum_i var(\varepsilon_i)]}\ , \tag{8}$$

where λ_i is the component loading of an indicator or variable and $var(\varepsilon_i)$ is the variance of the measurement error which is given as $1 - \lambda_i^2$. An AVE value greater than or equal to 0.5 is indicative of sufficient degree of convergent validity. That means the indicators' variance is explained by more than half of the LV (Jörg Henseler et al., 2009).

5.12.1.4 Discriminant Validity

Discriminant validity is assessed through two known measures – cross-loadings and the Fornell-Larcker criterion. The first measure is using the indicators cross-loadings. With the first criterion, the outer loading of an indicator associated with an LV or construct must be greater than all its loadings on the other LVs or constructs, also referred to as cross-loadings. The second, Fornell-Larcker criterion, ensures that each LV is greater than the LV's highest squared correlation with any other LV (Hair, Hult, et al., 2014; Hair et al., 2011; Urbach & Ahlemann, 2010). This study used this approach in assessing the discriminant validity of the outer model.

5.12.2Structural (Inner) Model Assessment

Once the measurement (outer) model is assessed, the inner model is evaluated. There are a few steps taken to evaluate the relationships that have been hypothesised within the inner model. The purpose of the inner model assessment, which is for prediction, is to be able to explain the variance of the LVs (Hair et al., 2011; Hair, Sarstedt, et al., 2014). The criteria often used to achieve this aim are the coefficient of determination of the endogenous LVs, R^2, predictive relevance using Stone-Geisser's Q^2, path coefficients, and the effect size, f^2. The sub-sections that follow elaborate on the measures used in the assessment of the structural (inner) model for this study.

5.12.2.1 Coefficient of Determination (R^2)

The coefficient of determination, R^2, serves as a measure of the predictive accuracy or explanatory power of the model. The value of R^2 ranges between 0 and 1, where 1 represents a complete or perfect predictive accuracy (Hair, Sarstedt, et al., 2014). The level of highness and lowness of R^2 values are entirely discipline dependent. In IS research, an R^2 value of 0,670 or higher is considered substantial, around 0,333 is considered moderate whereas a value around 0,190 and lower is considered weak (Chin, 1998; Urbach & Ahlemann, 2010).

5.12.2.2 Path Coefficients and Hypothesis Testing

A PLS-PM provides path coefficients (β) between constructs when complete. The path coefficient serves as a measure for the hypothesised relationships between the constructs or LVs (Hair, Sarstedt, et al., 2014; Roky & Al Meriouh, 2015). Regarding the path coefficients, the algebraic sign, magnitude and significance are used in the analysis. When the signs of paths contradict theoretical assumptions made about the existing relationships among the constructs, the pre-postulated hypothesis and claims are thus not supported (Urbach & Ahlemann, 2010).

This research tests the hypotheses and the existing relationships between the various constructs of the structural (inner) model through the analysis of the path coefficients and the corresponding t-values using bootstrapping. Bootstrapping is advised to determine significance (Goodhue, Lewis, & Thompson, 2007; Urbach & Ahlemann, 2010). The non-parametric bootstrap is simply a technique that provides an estimate for the spread, shape, and bias of the sampling distribution of a particular statistic (Jörg Henseler et al., 2009). With the results of the bootstrap, the significance of the various path model relationships can be measured using a t-test (Hair et al., 2011).

According to Roky & Al-Meriouh (2015), t-values at the various p-values are required for significance. For $p < 0.001$, which indicates very high statistical significant relationship, the t statistic value must be greater than or equal to 3.29; for $p < 0.01$, indicating high statistical significance relationship, the t static should be greater than or equal to 2.57; and for $p < 0.05$, indicating a statistically significant relationship, the t statistic should be greater than or equal to 1.96.

5.12.2.3 Goodness of Fit (GoF) Index

The GoF serves as means of validating a PLS model globally (Tenenhaus et al., 2005). It is represented mathematically as

$$GoF = \sqrt{\overline{AVE} \times \overline{R^2}} \tag{9}$$

Where $\overline{AVE}$ is the average AVE (communality), and $\overline{R^2}$ is the average R^2 of the endogenous constructs with $0 \leq GoF \leq 1$. In accordance with effect sizes for R^2 (small – 0,02; medium – 0,13; large – 0,26), the GoF index can be interpreted as $GoF_{small} = 0{,}1$, $GoF_{medium} = 0{,}25$ and $GoF_{large} = 0{,}36$ (Tenenhaus et al., 2005; Wetzels, Odekerken-Schröder, & Oppen, 2009).

5.13 SAMPLING STRATEGY

The purpose of the study was to develop a success model for water management information systems. To answer the research questions posed for this study, and to test and validate the proposed success model, the Water and Sanitation Department of the City of Cape Town (CoCT), South Africa was chosen as the unit of study. The choice of the CoCT, the sampling frame, sampling method, and sample size will be discussed in the sections that follow.

5.13.1 City of Cape Town Department of Water and Sanitation as the Target Population

Cape Town is the capital of the Western Cape province and the legislative capital of South Africa. The local government of Cape Town is the City of Cape Town metropolitan municipality (CoCTMM), and it accounts for as much as 50% of the economic activities in the Western Cape. The population of the City of Cape Town is 3,740,026 according to the 2011 South African census[6] data. The CoCTMM provides services to an area covering 2,455 square kilometres in the Western Cape. It is divided into 24 sub-councils which are subsequently divided into 116 geographical areas known as wards (CoCT, 2016). The CoCTs Water and Sanitation Department serves as both WSA and WSP. This means the city has constitutional and operational oversight and responsibility for the provision of water and sanitation services (CoCT, 2017). The CoCTMM Water and Sanitation Department is responsible for water services provision with a staff of about 4,000. The CoCT Water and Sanitation Department services the water infrastructure in the entire city. This includes three major dams and eight smaller ones, 12 water treatment plants, 25 bulk reservoirs, 23 wastewater treatment facilities, 400 pump stations, 38 maintenance depots, 3 marine outfalls, and a massive 20,000 km in reticulation network [7].

The CoCTMM was chosen as the target population for a number of reasons. It has structures and systems that have consistently made it the best-run municipality overall in the past years (GGA, 2016a, 2016b). The CoCTMM is considered to have ample capacity and skill compared to most of the other metropolis although the dearth of skilled workers in the water sector has been acknowledged in general in South Africa (Moodley, 2014; Tancott, 2014). Further, the city has consistently been ranked very high in the DWS's Blue Drop System (BDS), a system for drinking

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[6] http://www.statssa.gov.za/?page_id=993&id=city-of-cape-town-municipality

[7] http://www.capetown.gov.za/Departments/Water%20and%20Sanitation%20Department

water quality regulation (CoCT, 2016; Lindfors, 2011). Finally, the location provided convenience regarding distance, access and cost, as I could easily visit during the early stage of the research.

Based on the above reasons, the City of Cape Town's Water and Sanitation Department was chosen as the target population of the study.

5.13.2 Sampling

Sampling refers to a subset of things or persons selected from a larger population, also called the sampling frame (Scott & Morrison, 2006, p. 219). Two sampling techniques are often referred to in literature – probability and non-probability sampling. Probability sampling technique is based on random methods whereas non-probability sampling is not based on random selection (Perumal, 2014, p. 128). The probability sampling methods are simple random sampling, stratified sampling, systematic sampling and cluster sampling. Some of the methods used in non-probability sampling are convenience sampling, purposive or judgement sampling, quota sampling and snowball sampling (Battaglia, 2011; Perumal, 2014). When the selection of members of the population is based on some criteria, a purposive sampling method is appropriate. In this study, a non-probability sampling technique was used to select the sample of participants. A purposive sample of WMIS users for operations and decision-making processes at the various levels of water management in the Water and Sanitation Department in the CoCT were chosen. There are many designations in the department, highly technical ones who are involved in aspects like reticulation, pump stations, and others. The aforementioned group are mostly onsite and do not regularly engage with the WMIS. The designations involved with the reticulation systems, pump stations and the other technical aspects are often in field did not fit the study, and hence the study had to purposively select the sample of interest. Users of the WMIS within the CoCT Water Department onsite offices were thus selected to partake in the research.

These group of people chosen were responsible for the everyday work processes – general operations and management – and decision making within the water management organisation. They have experience with the use of water management information systems for their various tasks and duties for operations and decision-making within the water management process.

5.14 ETHICAL CONSIDERATIONS

The ethical considerations concerning the research particularly the collection of data for the research were done within two institutions – Faculty of Commerce at the University of Cape Town and the City of Cape Town. Each of the processes is described under the sections for the respective institutions.

5.14.1 University of Cape Town Ethics

As a requirement for studies involving any form of data collection, the University of Cape Town requires its students to apply for ethical clearance. Ethics clearance for this research was applied for in the Faculty of Commerce Approval was granted by the faculty for the conduct of this research. The acknowledgement was received via email communication with the approval letter attached (See for the Appendix F approval letter from the faculty).

The University of Cape Town provides a set of guidelines for researchers to follow on the instrument requirements. The instrument was thus designed to meet these standards that seek to protect both the university, researcher and participants.

5.14.2City of Cape Town Metropolitan Municipality

Once ethical clearance had been approved by the faculty ethics committee, the next stage was to apply for clearance from the City of Cape Town (CoCT) to carry out the research. Ethical clearance was applied for in April 2016, and the approval was granted in May 2016. A copy of approval from the CoCT is found in Appendix G .

5.15 SUMMARY

This chapter outlined the research methodology. To begin with, the chapter justifies the choice of a positivist philosophy and presents a detailed research design including the use of survey research for this study.

The chapter further elaborates on the research instrument process. The discussion continues with construct specification, development of the research instrument, indicator or item scaling, pretesting, pilot study and content validity. I justify the constructs and items based on existing literature, and where I introduce a construct or indicator, I explain. Finally, I discuss data collection strategies, follow-up procedures and response rate for the data collection section. An acceptable response rate was achieved based on the follow-up procedures employed.

Validation of the data obtained has also been presented. The section thoroughly discussed data accuracy, checking for missing data and outliers. As discussed in the section, the approach to data collection ensured data accuracy and the avoidance of the problem of missing data. The study employed a visual approach to the identification of outliers. None of the items had outliers that could cause issues with the analysis. An essential aspect of data validation is ensuring various catering for biases. As established in the literature, the non-response bias and common method bias are two essential biases that must be checked. The section discussed each of the biases and the approaches to be taken to assessing them.

The approach to data analysis and interpretation was discussed. The section introduces structural equation models (SEM) and then presents the theoretical foundation for the use of partial least squares (PLS) in solving the SEM. Based on the PLS approach taken, a discussion on the methods of assessment of the measurement and structural models were presented. Under the measurement model assessment, the internal consistency reliability, indicator (item) reliability, convergent validity and discriminant validity are discussed. For the structural model assessment, the coefficient of determination (R^2), path coefficients and hypothesis through bootstrapping, and predictive relevance (Q^2) are discussed.

Concluding the chapter is a discussion on the ethical considerations for this research. The section elaborates on the ethics application process for both the University of Cape Town and the City of Cape Town Water Services.

In Chapter 6, I present the analysis and results of empirical data systematically based on the research methodology.

6 ANALYSIS OF DATA AND RESULTS

6.1 INTRODUCTION

This chapter presents the results of the data analysis. The collection of empirical data was done as described in the research methodology chapter. This chapter discusses the results of the analysis performed and how these answers the aims and objectives set out in 1.

6.2 SUMMARY STATISTICS

The summary in Table 6-1 provides details of the respondents in the study. The descriptive statistic covers demographics and the age categories, gender and the years of system use categories obtained from the survey.

Table 6-1: Respondents' Gender and Ages

Attribute	Category	Frequency	%
Gender	Male	173	64,8
	Female	94	35,2
Age (in years)	18 – 29	80	30,0
	30 – 39	110	41,2
	40 – 49	57	21,3
	50 – 59	19	7,5

In Table 6-1 above, the frequencies and percentages of the gender and age attributes for respondents are presented. It is observed that out of a total of 267 respondents, 94 of them were female representing 35,2% and 173 of them were female, representing 64,8%. For the age attribute, three age groups – 18-29, 40-49 and 30-39 – have the highest number of respondents. These three groups have 57, 80 and 110 respondents respectively representing 21,3, 30,0 and 41,2%. The last age group category, 50-59, represent 7,5%.

Table 6-2: Respondents' years of system use and educational level

Attribute	Category	Frequency	%
Years of Use	1 – 5	93	34,8
	>5	174	65,2
Educational Level	Postgraduate	73	27,3
	Bachelor	139	52,1
	High School	36	13,5
	Other	19	7,1

Table 6-2 presents two attributes – years of use of the WMIS and the educational levels of the users. The mean number of years for the use of the system was 4,99 years with a standard deviation of 2,96.

In Table 6-3, the various designations of the respondents are presented. Of the 267 participants, 82 of them were professional officers, representing 30,7%, 45 of them were managers, representing 16,9%, 4 of them were administrative officers, representing 1,5% , 20 were engineers, representing 7,5%, 14 were laboratory assistants, making up 5,2% , 62 technicians representing 23,2% and all other designations were 77, representing 13,9%.

Table 6-3: Summary of Respondents Designations

Designation	Frequency	%
Professional Officers	82	30,7
Managers	45	16,9
Administrative Officers	4	1,5
Engineers	20	7,5
Laboratory Assistants	14	5,2
Technicians	62	23,2
Others	77	13,9

Professional officers consisted of both senior, principal and assistant professional officers, managers consisted of directors, district managers, area managers, project managers, deputies and section heads; engineers consisted predominantly of civil, process control officers, and electrical engineers, and others consisted of all respondents outside the listed, student interns, conservation officers, scientific officers, maintenance officers, data coordinators and others all within the City of Cape Town water and sanitation department.

6.3 DEALING WITH BIASES

Earlier in sections 5.8.1 and 5.8.2, two common sources of bias – nonresponse and common method bias – were discussed. The section discussed the relevant test and criteria for dealing with these two common sources of bias as explained in the literature. The sections that follow immediately discuss the outcome of the tests that were undertaken to address the stated biases.

6.3.1 Non-response Bias

To check for non-response bias in the data, a test for statistical significance was undertaken. As elaborated earlier in section 5.8.1, there is the need to compare the responses from earlier and later respondents.

Table 6-4: Nonresponse bias results summary based on the Demographics – Age Group, Years of Use, Gender and Education Level

	Age Group	Years of Use	Gender	Education Level
Wilcoxon (W)	8145	9386	8024	8511
p	0.570	0.137	0.375	0.951

A comparison was made to test for statistical significance between 104 early respondents and 163 late respondents using age group, gender, years of system use and educational level. As seen in Table 6-4 there was no significant difference at a 5% significance level between the early and, late respondents based on the Wilcoxon test carried out. The suggestion then was, nonresponse bias was not a concern.

6.3.2 Common Method Bias

In testing for common method bias (CMB) or common method variance (CMV), Harman's single-factor test which was introduced earlier in section 5.8.2 is used. It is a widely known and effective approach to addressing common method bias (Gorla et al., 2010; Malhotra et al., 2006; Podsakoff, 1986; Urbach & Ahlemann, 2010). A CMB is said to exist if two things occur; (1) a single factor emerges from the unrotated factor solutions (2) a first factor explains the majority of the variance in the variables (Malhotra et al., 2006, p. 1867; Podsakoff, 1986, p. 536).

For this study, the approach taken was the analysis of all the 48 items from the data using principal component analysis (PCA).

Table 6-5: Summary of PCA for the WMIS Response Data

	Component									
	1	2	3	4	5	6	7	8	9	10
Eigen value	8,883	6,475	4,181	3,730	2,969	2,481	2,095	1,563	1,386	1,119
Proportion of Variance	0,185	0,135	0,087	0,078	0,062	0,052	0,044	0,033	0,029	0,023
Cumulative Proportion	0,185	0,320	0,407	0,485	0,547	0,598	0,642	0,675	0,703	0,727

As seen from the analysis in the scree plot in Figure 6-1 and the summary provided in Figure 6-1, 10 of the components have eigenvalues greater 1 (Falissard, 2012, p. 189).

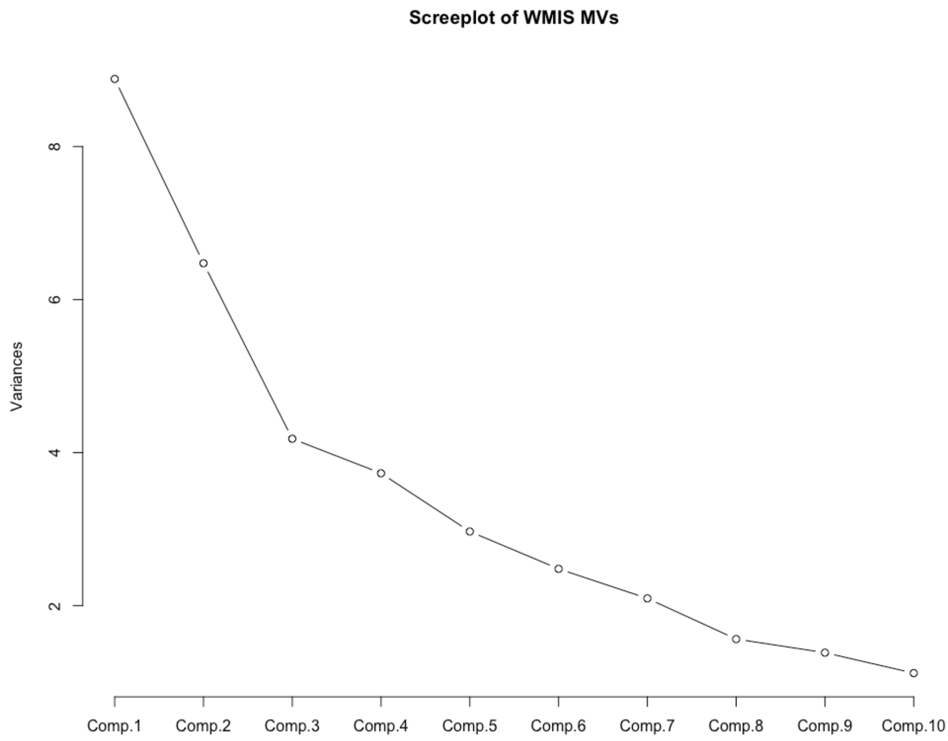

Figure 6-1: Scree Plot of the Components

The analysis in Table 6-5 furthers shows that the proportion of variance that the first component, which is the highest occurring eigenvalue, explains 18.5% of the variation. This value is far less than 50% which means common method bias did not exist.

6.4 ANALYSIS OF THE DEVELOPED MODEL

As discussed above, for sound model validation, the measurement and structural models must be thoroughly analysed. The order of analysis is critical in any PLS SEM model. The analysis was done using the PLSPM package developed by Gaston Sanchez (2013) and implemented in R. This study used plspm version 0.4.9 in RStudio version 1.0.143 running R (version 3.4.0)

Based on the method suggested by Chin (1998, p. 311), the respondents required would be 60. However, this study had 267 respondents. This number is greater than the suggested value, and thus the PLS approach used to solve the problem was highly appropriate.

In the sections that follow, the results from the measurement and structural models are presented.

6.4.1 Assessment of the Measurement (Outer) Model

Evaluation of the measurement model is part of the process of ensuring consistency and validity of the construct measures (Hair, Sarstedt, et al., 2014; Memon & Rahman, 2014; Vinzi, Chin, et al., 2010). While evaluation of the consistency is done through individual MVs and test of construct reliability, the validity of the variables employed are done through convergent and discriminant validity (Hair, Sarstedt, et al., 2014; Memon & Rahman, 2014). The assessment of the outer model ensures the quality of the constructs for the developed model.

6.4.1.1 Internal Consistency Reliability

As discussed earlier in section 5.12.1.1, internal consistency for the outer model is assessed through three known measures; Cronbach's alpha, Composite Reliability (CR) and the first eigenvalue of the correlation matrix of the MVs. These three measures are a measure of the unidimensionality of the model which is often seen in the literature. Composite reliability is known to provide an accurate measure of the reliability of internal consistency than the more traditional Cronbach's alpha. The Dillon-Goldstein (DG) rho is used in this case to assess the internal consistency reliability (Hair, Sarstedt, et al., 2014; Vinzi, Trinchera, et al., 2010).

Table 6-6: Internal Consistency Reliability Measures of the LVs

Construct	Code	MVs	DG. rho	Eig. Value(1st)
WMIS System Quality	WSQ	5	0,882	3,001
WMIS Information Quality	WIQ	5	0,937	3,420
Service Quality	SQ	5	0,916	3,423
System Use	SU	4	0,884	2,628
User Satisfaction	US	5	0,896	3,170
Leadership	LP	5	0,937	3,744
Structure	SE	4	0,902	2,793
Environment	ET	4	0,902	2,792
WMIS for Decision Making	WDM	5	0,912	3,381
WMIS for Operations	WMO	3	0,855	1,998

As seen in Table 6-6, each of the DG rho values is greater than the 0,70 criteria value discussed earlier. The CR value measures range between 0,855 and 0,937 and with eigenvalues ranging between 1,998 and 3,744. Based on the results, the constructs indicated good internal consistency reliability.

6.4.1.2 Indicator (Item) Reliability

For an indicator (item) to be deemed reliable, the outer loadings of the constructs must be greater than 0,70 as discussed in section 5.12.1.2. According to Hair et al. (2011), outer loading values between 0,40 – 0,70 should be removed and the model re-run.

Based on this well-known criterion, the outer loadings for all the MVs were examined to ensure this condition is met. In all, out of the 48 MVs present in the model, only three indicators – WSQ_6, WWMO_3 and WWMO_4 – did not meet the criteria.

Indicator WSQ_6 which falls under the WMIS System Quality construct had a loading of 0,69. The WSQ_6 indicator related to the effect of the number of licenses on the use of the WMIS. Though this came up during the earlier part of the study when discussions were being held with some users and stakeholders, it became clear that the quality of the WMIS was not affected by this indicator. A further examination showed that licensing was constrained to a section of the water department and hence was not the held opinion. Accordingly, removal of the indicator did not negatively affect it but instead enhanced the overall internal consistency reliability of the WSQ construct as seen in Appendix D .

The next two indicators to be removed from the model were WMMO_3 and WMMO_4. This first of the two indicators, WMMO_3, had a loading of 0,41 whiles the second indicator WMMO_4 has a loading of 0,70. Both indicators fall under the Water Management Operations construct. The MV WWMO_3 was "*The WMIS enhances water management administrative duties*", and the MV WWMO_4 was "*The WMIS enhances transparency and inclusivity in water management operations*". The second MV though had a loading of 0,70, did not meet the communality criteria (>= 0,50) and hence was removed from the model. Though these MVs came up in the literature, respondents did not find it relevant based on the results obtained. In the context of the study, the indicator was not relevant and had to be removed. Like the previous indicator that was removed, re-running the model enhanced the internal consistency reliability of the WMIS for Water Management Operations construct.

Table 6-7: Indicators removed from the model

Construct	MV Code	Question Posed
WMIS System Quality	WSQ_6	The number of WMIS licenses available affects use of the WMIS
WMIS for Water Management Operations	WMMO_3	The WMIS enhances water management administrative duties
WMIS for Water Management Operations	WMMO_4	The WMIS enhances transparency and inclusivity in water management operations

A total of 45 indicators remained for use in the subsequent analysis after the removal of the two indicators discussed above. The loadings and AVEs improved on the removal of these three and reran the model. Factor loadings and CR values can be found in Appendix B and Appendix C .

6.4.1.3 Convergent Validity

For the convergent validity of the model, the factor loadings, composite reliability and average variance explained (AVE) are used to assess the convergent validity as discussed in section 5.12.1.3.

Table 6-8: Results for assessing Convergent Validity

Construct0	Code	CR	AVE
WMIS System Quality	WSQ	0,882	0,60
WMIS Information Quality	WIQ	0,937	0,68
Service Quality	SQ	0,916	0,67

System Use	SU	0,884	0,66
User Satisfaction	US	0,896	0,63
Leadership	LP	0,937	0,75
Structure	SE	0,902	0,70
Environment	ET	0,902	0,69
WMIS for Decision Making	WDM	0,912	0,67
WMIS for Operations	WMO	0,855	0,65

Whereas the composite reliability values must be greater than 0,70 as has already been discussed, the AVE values must be greater than or equal to 0,50, and each factor loading should also be greater than 0,70.

As can be observed from Table 6-8, the minimum CR value is 0,855 which is greater than the 0,70 criteria, and each of the loadings (See Appendix A) is greater than 0,70 with the least of the loadings being 0,7462. The AVE values were above the recommended 0,50 with the least of the AVEs being 0,60. The above values justified convergent validity.

6.4.1.4 Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion(Gefen et al., 2000; Straub et al., 2004). Here, the square root of the AVE for each of the constructs is compared with the correlation between the other constructs. From Table 6-9, the square root of the AVEs for the constructs as seen along the diagonal is greater than 0,50 and greater than the correlations between the constructs, that is the off-diagonal elements. The constructs' discriminant validity can thus be said to be sufficient. Also, the discriminant validity can be determined using the cross-loadings for the constructs.

Table 6-9: Square Root of the AVEs Compared to the Correlation Between the Constructs

	WSQ	LP	SQ	WIQ	ET	US	SU	SE	WMO	WDM
WSQ	**0,772**									
LP	-0,016	**0,865**								
SQ	0,171	0,028	**0,827**							
WIQ	0,164	0,146	0,052	**0,826**						
ET	-0,033	0,006	0,026	-0,011	**0,835**					
US	0,123	0,069	0,608	0,079	0,076	**0,795**				
SU	0,181	0,113	0,055	0,235	-0,027	0,062	**0,811**			
SE	0,090	0,225	0,125	0,034	-0,059	0,108	-0,008	**0,834**		
WMO	0,151	0,113	0,438	0,142	0,129	0,537	0,146	0,040	**0,810**	
WDM	0,165	0,156	0,052	0,617	-0,015	0,078	0,231	0,039	0,121	**0,820**

With this approach, the indicator loadings of a particular construct that it is intended to measure, loads higher on that very construct than on the other constructs (Chin, 1998; Koh, Prybutok, Ryan, & Wu, 2010). This can be seen in Table C-1, and the results also show that the constructs' have sufficient discriminant validity.

6.4.2 Assessment of Structural (Inner) Model

The assessment of the structural (inner) model follows on from the measurement model. From the discussion in section 5.12.2, the approaches to be taken to assess the structural (inner) model was presented. As discussed in the section, the path coefficients, the statistical significance of the path coefficients, the hypothesised relationships, and the coefficients of determination (R^2) for the endogenous constructs are relevant for this assessment.

The strength of the relationship between dependent and independent variables are assessed via the standardised path coefficients. The R^2 value is the amount of variance explained by the independent variables. Further, validation using a bootstrapping method applied with 500 resamples or subsamples. The bootstrap results produced results for the outer weights, factor loadings, path coefficients and the total effects for each of the paths. The path coefficients are further explained through the direct and total effect of the various paths for the endogenous variables. Chin (1998) found paths coefficients which were greater than 0,2 to be significant.

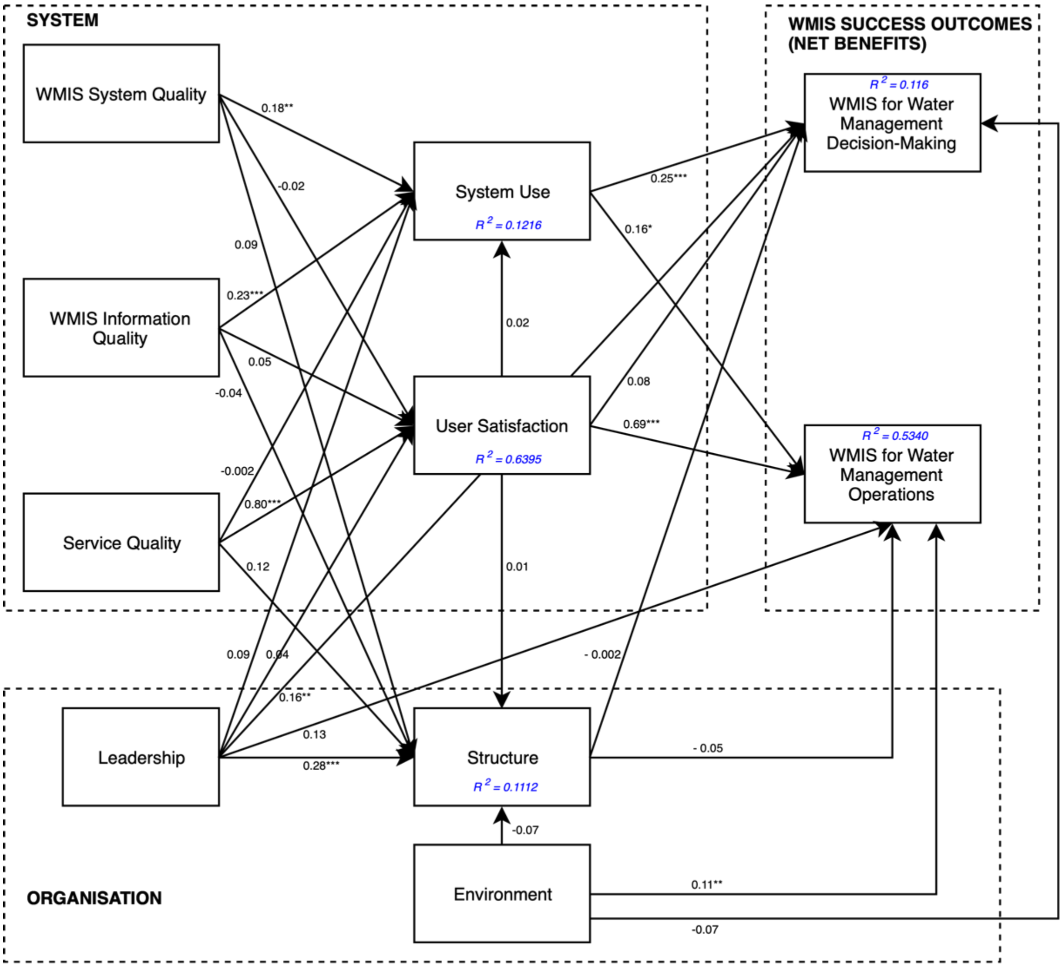

Figure 6-2: Summary of Path Coefficients, Significance Level and R^2 values of the Model

The sections that follow will provide a thorough result and explanation of the structural model.

6.4.2.1 H_{1a}, H_{1b}, H_{1c} WMIS System Quality has a significant positive effect on System Use, User Satisfaction and Structure

As can be seen from the summary presented in Table 6-10, there were three hypotheses in all emanating directly from WMIS System Quality. Of the three, only one, H_{1a}, was supported. The results for each of the hypothesis is presented in the table.

Hypothesis H_{1a} was supported, that is WMIS System Quality had a significant positive effect on System Use. The effect size was small to moderate ($\beta = 0{,}18$). This suggested that the perceived quality of the WMIS by the users influenced its use. From the discussion in section 4.5.1.1, the outcome from various studies was mixed. Whereas some reported some studies like Qutaishat (2013) found a significant positive effect, Erlirianto et al., (2015) find a significant positive effect between the two constructs.

Table 6-10: Effect of WMIS System Quality on System Use, User Satisfaction and Structure

Hypothesis	Path	β	p (t value)	Result
H_{1a}	WMIS System Quality → System Use	0,18	0,004 (2,91)**	Supported
H_{1b}	WMIS System Quality → User Satisfaction	-0,02	0,68 (-0,41)	Not Supported
H_{1c}	WMIS System Quality → Structure	0,09	0,14 (1,49)	Not Supported
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$				

Indeed, responses are consistent with studies in other disciplines where the claim has been made. However, this study will be the first to establish a relationship between WMIS System Quality and System Use with varying size effects, β. Particularly, this result is the first study to report a significant positive effect between WMIS System Quality and System use with moderate effect size (β=0,18).

6.4.2.2 H_{2a}, H_{2b}, H_{2c} WMIS Information Quality has a significant positive effect on System Use, User Satisfaction and Structure

The summary of the results for hypotheses H_{2a}, H_{2b}, and H_{2c} is presented in Table 6-11. The result shows that for hypothesis H_{2a}, WMIS Information Quality had a significant positive effect on System use and hence was supported by a moderate size effect (β=0,23).

Table 6-11: Effect of WMIS Information Quality on System Use, User Satisfaction and Structure

Hypothesis	Path	β	p (t value)	Result
H_{2a}	WMIS Information Quality → System Use	0,23	<0,001 (3,83)***	Supported
H_{2b}	WMIS Information Quality → User Satisfaction	0,05	0,22 (1,16)	Not Supported
H_{2c}	WMIS Information Quality → Structure	-0,04	0,55 (-0,61)	Not Supported
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$				

Like the previous hypothesis, there are mixed results from the IS literature. Some studies have supported this relationship whiles other studies have not supported it (Fitzgerald & Russo, 2005; Iivari, 2005; Petter et al., 2008). This study thus aligns with what is in the literature and particularly provides a new perspective in the context of WMISs.

6.4.2.3 H_{3a}, H_{3b}, H_{3c} Service Quality has a significant positive effect on System Use, User Satisfaction and Structure

Again, we see the summary of the results for the above hypotheses in Table 6-12. By far, the Service Quality – User Satisfaction relationship, H_{3b}, has the most contribution by effect size of all the constructs is the supported hypotheses. Service Quality has a direct effect on User Satisfaction with a large effect size of β=0,80.

Table 6-12: Effect of Service Quality on System Use, User Satisfaction and Structure

Hypothesis	Path	$\boldsymbol{\beta}$	$\boldsymbol{p}$ (t value)	Result
H_{3a}	Service Quality → System Use	-0,002	0,98 (0,06)	Not Supported
H_{3b}	Service Quality → User Satisfaction	0,80	<0,001(20,95)***	Supported
H_{3c}	Service Quality → Structure	0,12	0,21 (1,25)	Not Supported
* $\boldsymbol{p < 0,05}$; ** $\boldsymbol{p < 0,01}$; *** $\boldsymbol{p < 0,001}$				

The relationship between service quality and user satisfaction is of practical significance to the study. The implication is that, when there are system administrators available to attend to challenges faced by the WMIS users, there is satisfaction with the system is highly favourable.

The finding for this relationship is consistent with studies in other disciplines. Erlirianto et al. (2015), who used the HOT-fit framework for the evaluation of an EMR system, reported a significant positive effect of service quality on user satisfaction with a large effect size (β=0,437). Akter et al. (2011) found a significant positive relationship with a medium size effect (β=0,348) in a mHealth service systems study and Choi et al., (2013) also found a similar result with medium effect size (β=0,296) in a CRM system study. The relationship has shown to be supported in the IS literature (DeLone & McLean, 2003; Petter et al., 2008; Pitt et al., 1995; Seddon, 1997).

6.4.2.4 H_{5a}, H_{5b} *System Use has a significant positive effect on WMIS for Water Management Decision-Making and Water Management Operations*

The summary of the results for System Use effect on WMIS for Water Management Decision-Making (H_{5a}) and WMIS for Water Management Operations (H_{5b}) are presented. The results established a significant positive effect of System Use on WMIS for Water Management Decision-Making (WDM) with a moderate size effect (β= 0,25) and hypothesis H_{5a}. Also, there was a significant positive effect of System Use on WMIS for Water Management Operations with a small to moderate effect size (β= 0,16) hence hypothesis H_{5b} was accepted.

Table 6-13: Effect of System Use on WMIS for Water Management Decision-Making and Water Management Operations

Hypothesis	Path	β	p (t value)	Result
H_{5a}	System Use → WMIS for Water Management Decision-Making	0,25	<0,001 (4,26)***	Supported
H_{5b}	System Use → WMIS for Water Management Operation	0,16	0,01 (2,53)*	Supported
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$				

Similarly, the effect of these two relationships have practical implication in that; the more users use the system, the likelihood that they will use the system for tasks that enhance water management operations and water management decision-making is higher. This should subsequently influence other aspects at the organisational level.

The effect of system use on net benefits, in general, has varied in the IS literature as seen in justification of the hypothesis (Petter et al., 2008). Thus, the result is consistent when what is found in the literature. Alshibly (2014) found a significant positive effect of system use on net benefits with a large effect size (β =0,64) in a study of e-HRM systems. Wang and Liao (2006) also found that system use had a significant positive effect, with a large effect size (β = 0,35), on net benefits in an assessment of an e-government system success. However, in a study that involved the evaluation of EMR system using a HOT-Fit framework, on which this model is derived, the results by Erlirianto et al. (2015) did not support this relationship Again, this study is the first to study the relation between System Use and WMIS for Water Management Operations and addresses the request for empirical studies on the relationship (Petter et al., 2008).

6.4.2.5 H_{6a}, H_{6b} User Satisfaction has a significant positive effect on WMIS for Water Management Decision-Making and WMIS Water Management Operations

The summary of hypotheses H_{6a} and H_{6b} is presented in Table 6-14. Hypothesis H_{6b} was supported, meaning user satisfaction had a significant positive effect on WMIS for Water Management Operations with a large size effect (β = 0,69).

Table 6-14: Effect of User Satisfaction on WMIS for Water Management Decision-Making and WMIS for Water Management Operations

Hypothesis	Path	β	p (t value)	Result
H_{6a}	User Satisfaction → WMIS for Water Management Decision-Making	0,08	0,20 (1,27)	Not Supported
H_{6b}	User Satisfaction →WMIS Water Management Operation	0,69	<0,001 (16,10)***	Supported
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$				

Again, the effect was of practical significance. The implication was that the more users were satisfied with the WMIS, there is a high possibility of using it for tasks and duties that enhance WMIS Water Management Operations.

The finding for this hypothesis is similar to that found in the IS literature. As seen in section 4.5.1.5, it is strongly supported by different studies. Ghobakhloo et al. (2011) found a significant positive effect of user satisfaction on organisational impact in a study of IT implementation success within SMEs in developing countries with large size effect (β = 0,33). Wang and Liao (2006) in a study of e-government systems success found a significant positive effect of user satisfaction on perceived net benefits also with a large size effect (β = 0,35). However, in the implementation of the HOT-fit framework to evaluate the EMR system, Erlirianto et al. (2015) did not find a significant positive effect of user satisfaction on net benefits.

6.4.2.6 H_{7a}, H_{7b}, H_{7c}, H_{7d}, H_{7e} Leadership has a significant positive effect on System Use, User Satisfaction, Structure, WMIS for Water Management Decision-Making and Water Management Operations

The summary of the result for hypotheses H_{7a}, H_{7b}, H_{7c}, H_{7d}, and H_{7e} is presented in Table 6-15. The effect of leadership on the constructs in the table below have not been studied extensively in some cases and non-existent in others.

Hypothesis H_{7c} was supported, and this implied that Leadership had a significant positive effect on WMIS for Water Management Decision-Making with a small to moderate size effect (β = 0,16).

The results for hypothesis H_{7c} has been consistent with some studies. Prybutok et al. (2008) in the evaluation of leadership, IT quality and net benefits in an e-government context found that leadership was positively related to net benefits with a small size effect (β = 0,15).

Table 6-15: Effect of Leadership on System Use, User Satisfaction, WMIS for Water Management Decision-Making, WMIS for Water Management Operations and Structure

Hypothesis	Path	$\boldsymbol{\beta}$	$\boldsymbol{p}$ (t value)	Result
H_{7a}	Leadership → System Use	0,09	0,09 (1,67)	Not Supported
H_{7b}	Leadership → User Satisfaction	0,04	0,27 (1,12)	Not Supported
H_{7c}	Leadership → WMIS for Water Management Decision-Making	0,16	<0,01 (2,61)**	Supported
H_{7d}	Leadership → WMIS for Water Management Operations	0,13	0,08 (1,75)	Not Supported
H_{7e}	Leadership → Structure	0,28	<0,001 (4,72)***	Supported

* $\boldsymbol{p < 0,05}$; ** $\boldsymbol{p < 0,01}$; *** $\boldsymbol{p < 0,001}$

Hypothesis $\boldsymbol{H_{7e}}$ was also supported which indicated that Leadership had a significant positive effect on Structure. The hypothesis was supported with a medium to large effect size (β = 0,28). It must be stated that from a practical point of view this result was expected. The relationship is not common in the literature, and hence this study provides empirical evidence with the aim of adding to and understanding leadership effect on organisational structure within the context of IS use and implementation.

6.4.2.7 H_{9a}, H_{9b}, H_{9c} Environment has a significant positive effect on Structure, WMIS for Water Management Decision-Making and Water Management Operations

The summary of hypotheses H_{9a}, H_{9b}, and H_{9c} are presented in Table 6-16.

Hypothesis H_{9c} was supported indicating that Environment has a significant positive effect on WMIS for Water Management Operations. The effect size of the support was small (β = 0,11). The practical significance of this relationship is that the institutions and establishments standards employed in the sector influence the use of the WMIS for the various water management operations.

Table 6-16: Effect of Environment on Structure, WMIS for Water Management Decision-Making and WMIS for Water Management Operations

Hypothesis	Path	$\boldsymbol{\beta}$	$\boldsymbol{p}$ (t value)	Result
H_{9a}	Environment → Structure	-0,07	0,23 (-1,19)	Not Supported
H_{9b}	Environment → WMIS for Water Management Decision-Making	- 0,02	0,69 (-0,38)	Not Supported
H_{9c}	Environment → WMIS for Water Management Operation	0,11	0,008 (2,20)**	Supported

* $\boldsymbol{p < 0,05}$; ** $\boldsymbol{p < 0,01}$; *** $\boldsymbol{p < 0,001}$

This result is consistent with the study by Erlirianto et al. (2015) in health through the effect size of the support was large (β = 0,625). A few comparisons can be drawn here. Though the frameworks were similar in many aspects, their study had only one net benefit compared to distinctions presented in model found in this study. Further, the discipline of application is different although they might share purposes for environmental factors.

6.4.2.8 Direct, Indirect and Total Effect of Dominant Constructs on WMIS for Water Management Decision-Making and WMIS for Water Management Operations

The direct, indirect and total effect of the dominant constructs on WMIS for Water Management Decision-Making and WMIS for Water Management Operations are shown in Table 6-17.

Table 6-17: Direct, Indirect and Total Effect of the Constructs on WMIS for Water Management Decision-Making and WMIS for Water Management Operations

	Direct Effect					Indirect Effect					Total Effect				
	SU	US	SE	WDM	WMO	SU	US	SE	WDM	WMO	SU	US	SE	WDM	WMO
WSQ	0,1767**	-0,0158	0,0917			-0,0003		-0,0001	0,0431	0,0037	0,176**	-0,016	0,092	0,043	0,004
WIQ	0,2317**	0,0449	-0,0370			0,0009		0,0003	0,0621	0,0581	0,2326**	0,0449	-0,0366	0,0621	0,0581
SQ	-0,0029	0,7957***	0,1223*			0,0161		0,0059	0,0631	0,5452***	0,0132	0,7957***	0,1282*	0,0631	0,5452***
LP	0,0991	0,0422	0,2823**	0,1606*	0,0779	0,0009		0,0003	0,0277	0,0261	0,1000*	0,0422	0,2826**	0,1883**	0,1040*
SE				-0,0024	-0,0492								0,0000	-0,0024	-0,0492
ET			-0,0702	-0,0227	0,1144*				0,0002	0,0035			-0,0702	-0,0226	0,1178*
SU				0,2522**	0,1087*									0,2522**	0,1087*
US	0,0203		0,0074	0,0756	0,6914***				0,0051	0,0018	0,0203		0,0074	0,0807	0,6932***

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

From the table, the result showed the strongest total effect on WMIS for Water Management Operations was User Satisfaction with 0,6932 of which 0,6914 was a direct effect. The direct and total effect of System Use on WMIS for Water Management Decision-Making was 0,2522. Service Quality had a sizeable effect on WMIS for Water Management Operations at 0,5452 but not as much as User Satisfaction did as seen from Table 6-17. Thus, User Satisfaction had a stronger direct and total effect on WMIS for Water Management Operations that System Use whereas System Use had a direct and total effect on WMIS for Water Management Decision-Making (WDM) than User Satisfaction in the technology dimension.

The direct and total effect of WMIS System Quality (WSQ) and WMIS Information Quality (WIQ) on WMIS for Water Management Decision-Making and WMIS for Water Management Operations were through System Use (SU) with values of 0,176 and 0,2317 respectively. Service Quality (SQ), of all the technology dimension constructs, had the strongest direct and total effect on WDM and WMO through User Satisfaction with 0,7957.

In the organisational dimension, the direct and total effect of Leadership on WDM was 0,1883 and was also direct through its fellow organisational construct, Structure. These two paths were statistically significant. Environment had a direct and total effect of 0,1144 and 0,1178 on WMO. It did not affect WDM. However. Thus, of the organisation dimension constructs, Environment (ET) had the strongest total effect on WMO whereas Leadership (LP) had the strongest total effect on WDM. Structure did not have a direct or indirect effect on both WDM and WMO in the model.

6.4.2.9 Variance Explained in the Constructs

To analyse and assess the strength and explanatory power of the endogenous (dependent) variables in the structural (inner) model, the coefficient of determination (R^2) was used. A summary of R^2 values for each of the endogenous variables are shown in Table 6-18.

Table 6-18: Summary of R^2 Values of the Endogenous Variables

Construct	R^2
User Satisfaction	0,6395
System Use	0,1216
Structure	0,1112
WMIS for Water Management Operations	0,5340
WMIS for Water Management Decision-Making	0,116

From the analysis presented in section 6.4.2.8, three constructs – System Use (SU), User Satisfaction (US) and Environment (ET) – had a direct effect on WMIS for Water Management Operations and that explained 53,40% of the variance ($R^2 = 0{,}5340$). Leadership (LP) and System Use (SU) on the other hand accounted for

11,6% of the variance ($R^2 = 0{,}116$) in WMIS for Water Management Decision-Making.

In the case of User Satisfaction, 63,95% of the variance was explained directly by Service Quality. WMIS System Quality (WSQ) and WMIS Information Quality (WIQ) accounted for 12.16% of the variance explained in System Use.

For Structure, 11,12% of the variance was explained by directly by Leadership. According to Falk and Miller (1992, p. 80), the variance explained (R^2) for the endogenous or dependent variables within the inner model should be greater than or equal 0,10 to validate the explanatory power of structural (inner) model. As can be seen from Table 6-18, all the R^2 values were greater the 10% recommendation proposed by Falk and Miller. Further, Cohen (1988) suggested the following criteria for the R^2 values of the endogenous constructs; 0,26 – substantial, 0,113 – moderate and 0,02 – weak. Other recommendations by Chin (1998) are seen in the literature. Thus, the conclusion can be drawn that model fit altogether was good based on the variance accounted for by the endogenous variables.

6.5 SUMMARY

Summary statistics of the respondents' ages, gender, number of years of use of the WMIS, designation and educational level was presented. The summary shows that out of a total of 267 respondents, 173 were male whiles the remaining 94 were female making up 64,8 and 35,2% respectively. The mean number of years of use of the WMIS was 4,99~5 years (SD = 2,96). Regarding educational level, it was observed that 52,1% of the respondents had postgraduate degrees, 13,5% were bachelor degree holders, 13,5% were high school graduates and remaining 7,1% had other qualifications or diplomas. Of the broad spectrum of WMIS users made up of various designations, 30,7% were professional officers, 16,9% were managers, 1,5%

were administrative officers, 7,5% were engineers, 5,2% were laboratory assistants, 23,2% were technicians and the rest (others) made up 13,9%. To ensure that biases were absent at the data collection stage, non-response bias and common method bias were undertaken. For non-response bias, 104 early respondents were compared to the 163 late respondents by performing a Wilcoxon test. The results showed that non-response bias was not an issue. Concerning the common method bias, Harman's single-factor test was conducted, and the result showed no evidence of CMB.

To assess the measurement (outer) model, the internal consistency reliability, indicator (item) reliability, convergent validity and discriminant validity was assessed. The measurement model indicated good internal consistency reliability with Dillon-Goldstein rho values ranging from 0,855 to 0,937, greater than the 0,7 threshold. The first eigenvalues ranged from 1,998 to 3,744, above the threshold of 1. The indicator (item) reliability test resulted in the removal of three indicators (items) from the outer model, namely WSQ_6, WMMO_3 and WMMO_4. The remaining 45 indicators on the re-run of the model had all the factor loadings greater than the recommended least value of 0,70. Convergent and discriminant validity was also assessed, and both passed the relevant tests.

For the structural (inner) model assessment, WMIS System Quality (WSQ) had a small to moderate effect on System Use (β = 0,18, $p = 0{,}004$, t–value = 2,91). WMIS Information Quality (WIQ) had an effect on System Use (SU) with a moderate size effect (β = 0,23, $p < 0{,}001$, t–value = 3,83). Service Quality (SQ) had an effect on User Satisfaction (US) with a large size effect (β = 0,80, $p < 0{,}001$, t–value = 20,95).

System Use (SU) had an effect on WMIS for Water Management Decision-Making with a moderate effect size (β = 0,25, $p < 0{,}001$, t–value = 4,26) and it also had an effect on WMIS for Water Management Operations with a small to moderate effect size (β = 0,16, $= 0{,}01$, t–value = 2,53).

User Satisfaction (US) had an effect on WMIS for Water Management Operations with a large effect size (β = 0,69, $p < 0{,}001$, t–value =16,10). However, US did not have an effect on WMIS for Water Management Decision-Making.

Leadership (LP) had an effect on WMIS for Water Management Decision-Making with a small to moderate effect (β = 0,16, $p < 0{,}001$, t–value = 2,61) and also had an effect on Structure (SE) with a moderate size effect (β = 0,28, $p < 0{,}001$, t–value = 24,72). Leadership did not however have an effect on WMIS for Water Management Operations.

Environment had an effect on WMIS for Water Management Operations with a small effect size (β = 0,11, $p = 0{,}008$, t–value = 2,20). It, however, did not have an effect on WMIS for Water Management Decision-Making.

The direct, indirect and total effect of constructs on WMIS for Water Management Operations and Water Management for Decision-Making were also presented. Service Quality had the strongest direct and total effect on Water Management Operations and Water Management Decision-Making through User Satisfaction in the technology dimension.

Environment had the strongest total effect on WMIS for Water Management Operations whereas Leadership had the strongest total effect on WMIS for Water Management Decision-Making in the organisation dimension.

Altogether, the variance explained (R^2) for the endogenous variables showed that the model had a large effect size and thus the model fit overall was substantial.

7 FINDINGS, DISCUSSION AND CONCLUSIONS

7.1 INTRODUCTION

This chapter presents the findings of the study based on the research question(s) posed in Section 1.2 and the hypotheses formulated. The purpose of this research was to answer the research question: "*What organisational and system factors can be used to develop a model for water management information systems success that supports efficient water resources management?*". Three sub-questions were posed to answer the research question as follows:

> RQ1: What organisational factors affecting the organisation's functions determine WMIS success?
>
> RQ2: What system factors determine the success of WMIS?
>
> RQ3: What IS success models can be used to derive a WMIS success model?

Conclusions are drawn based on the findings presented. The chapter continues with contributions of this research to theory and also to water management practice. The chapter concludes with a presentation on the limitations of the study and suggestions are made for further research.

In the section that follows immediately, I present an overview of the study.

7.2 STUDY OVERVIEW AND SUMMARY OF EMPIRICAL FINDINGS

To answer the main research question, a proposed model for water management information systems success – WMIS Success Model (WSM) – was developed. The proposed model was based on the HOT-Fit Framework by Yusof et al. (2008) which has roots in the updated DeLone and McLean IS success model (2003) and IT-

Organisation fit model. The model by Yusof et al. (2008) was modified by the inclusion of a leadership construct in the organisation factors; and adding two new constructs to represent WMIS success, WMIS for Water Management Operations and WMIS for Water Management Decision-Making; maintaining the five constructs that represent the system from the updated DeLone and McLean (2003) IS success model. A total of eight constructs measured WMIS success which was represented by two net benefits constructs – WMIS for Water Management Operations and WMIS for Water Management Decision-Making: 1) WMIS System Quality, 2) WMIS Information Quality, 3) Service Quality, 4) System Use, 5) User Satisfaction, 6) Structure, 7) Environment and 8) Leadership. The proposed model and the set of hypotheses that were formulated in Chapters 3 and 4 of this study were empirically validated and tested in the water resources management context. The study formulated a total of 25 hypotheses (*H1a-H9c*) which were clustered under the 8 constructs that determined the success of WMIS.

The study collected data from the Water and Sanitation Department of the City of Cape Town Metropolitan Metropolis for model validation and hypotheses testing. Collection of data was done via a questionnaire. A Partial Least Squares (PLS) Structural Equation Modelling (SEM) approach was taken to validate the model and test the hypotheses after the necessary data checks and validations were done. The results of the validation and hypotheses testing are presented in Chapter 6 of this thesis. The findings of the research showed that the proposed model explained WMIS success in the water resources management context and the findings for the constructs were consistent with the literature in both IS and water resources management.

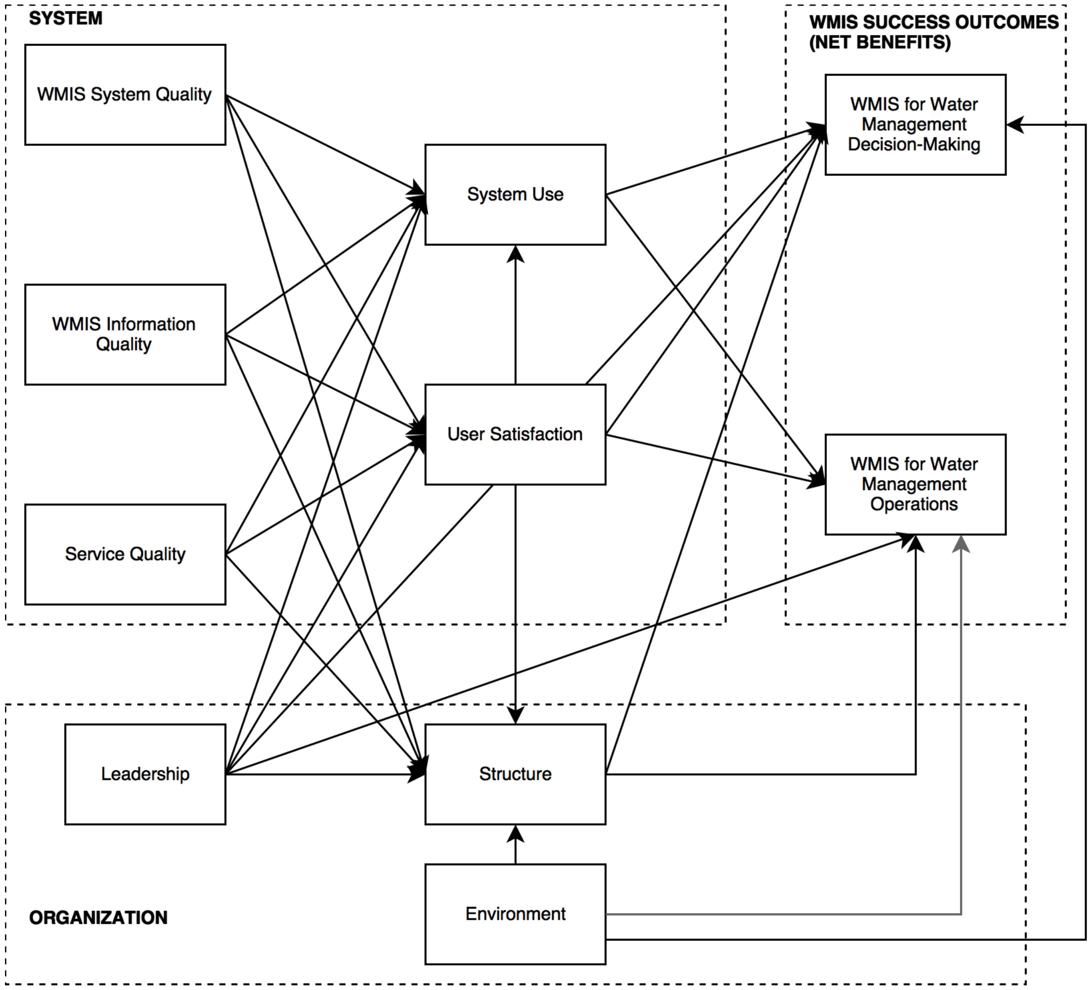

Figure 7-1: The WSM that was proposed and validated

In terms of the system factors, the structural (inner) model assessment showed that WMIS System Quality (WSQ) had a small to moderate effect on System Use (β = 0,18, $p = 0{,}004$, t–value = 2,91). WMIS Information Quality (WIQ) had a moderate effect on System Use (SU) (β = 0,23, $p < 0{,}001$, t–value = 3,83) and Service Quality (SQ) had an effect on User Satisfaction (US) with a large size effect (β = 0,80, $p < 0{,}001$, t–value = 20,95). System Use (SU) also had an effect on WMIS for Water Management Decision-Making with a moderate effect size (β = 0,25, $p < 0{,}001$, t–value = 4,26), and it also affect WMIS for Water Management Operations with a small to moderate effect size (β = 0,16, $= 0{,}01$, t–value = 2,53). User Satisfaction

(US) had an effect on WMIS for Water Management Operations with a large effect size (β = 0,69, $p < 0{,}001$, t–value =16,10). User Satisfaction did not, however, have an effect on WMIS for Water Management Decision-Making.

For the organisational factors, the analysis showed that Leadership (LP) had an effect on WMIS for Water Management Decision-Making with a small to moderate effect (β = 0,16, $p < 0{,}001$, t–value = 2,61) and it also had an effect on Structure (SE) with a moderate size effect (β = 0,28, $p < 0{,}001$, t–value = 24,72). It did not, however, have an effect on WMIS for Water Management Decision-Making. Environment had an effect on WMIS for Water Management Operations with a small effect size (β = 0,11, $p = 0{,}008$, t–value = 2,20

Regarding the direct, indirect and total effect of constructs on WMIS for Water Management Operations and Water Management for Decision-Making, Service Quality had the strongest direct and total effect on Water Management Operations and Water Management Decision-Making through User Satisfaction in the system dimension. Environment had the strongest total effect on WMIS for Water Management Operations whereas Leadership had the strongest total effect on WMIS for Water Management Decision-Making in terms of the organisation factors. The variance explained (R^2) for the endogenous variables of the proposed model showed that the model had a large effect size and thus the overall model fit was substantial.

This research has met the objectives set at the beginning of the study by developing a model to understand water management information systems success in a water resources management setting. I will discuss how each of the sub-objectives of this research was achieved.

I further present the main findings of the study regarding the sub-questions, which was captured through the proposed model and set of hypotheses.

> ***RQ1: What organisational factors affecting the organisation's functions determine WMIS success?***

Discussion of the findings on three organisational constructs relating to the functions and responsibilities of water management organisations which affect WMIS success are presented.

Leadership

In this study, the operational definition of leadership was given as the satisfaction of the perception of support provided by the leadership, ability to mobilise and their understanding of the WMIS. The findings showed that leadership had a significant positive effect on one of the organisational constructs, that is Structure, and it also had a positive significant effect on WMIS for Water Management Decision-Making. The effect size of Leadership on Structure was medium to large whereas the effect size on WMIS for Water Management Decision-Making was little to medium. It did not affect WMIS for Water Management Operations.

The leadership constructs were operationalised via variables belong to two leadership forms; transactional and transformational leadership. There were five operationalised item and all the items, LP_1 to LP_5, loaded highly on the leadership. The item, LP_1, sought to understand the perception WMIS users had of the role of leadership in ensuring that the needed support is provided when they encounter challenges in the use of the WMIS for their duties and functions. The findings then suggested that users of the WMIS perceive a leaders' transformational leadership abilities to ensure that needed support is provided when they encounter challenges as an essential characteristic and requirement.

Item LP_2 had a very high loading on the leadership construct too, and that also suggested from the findings that within the water management organisations, leaders, superiors and designation heads must commend and appreciate their subordinates when they produce work outcomes that affect the decision-making processes within the organisation. This typifies the importance of a transactional leader. Again, the LP_3 item was to understand the ability of leadership to follow-up on tasks and be able to curtail errors before it affects the processes. This aspect is important as, for example, when dealing with water quality, the water management organisation always wants to ensure strict standards in their monitoring (Souza et al., 2009). The findings suggest that users regarded these follow-ups as critical in ensuring that the standards and quality within the processes are maintained. This has a bearing both on the organisational structure and the outcomes of the WMIS on water management decision-making process including policies, regulations, and related activities. With the strong loading of LP_4 on leadership, WMIS users felt the need for various designation heads to have a good understanding of the WMIS functions. It will thus be easier to consult them when the need arise than follow through with other support team members. Finally, leaders are expected to support and encourage working together and also being able to ask colleagues when the need arose.

The results are consistent with the literature as in the study of the impact of transactional and transformational leadership on organisational performance in a water management organisation in Akwa Ibom, Uyo, Nigeria, Ejere and Abasilim (2013) found that both transformational and transactional leadership styles have a significant positive relationship on the organisational performance in general. They thus recommended the use of a mix of both, which this study has done. Taylor (2016) also found out in a study of Australian water utilities that, leadership was identified as the most critical enabling factor for effective management of water utilities. It came out that effective leadership requires the mix of transactional and transformational leadership abilities.

Studies in other areas have reported similar findings Prybutok et al. (2008) found that leadership positively affected net benefits with a small size effect. The effect of Leadership on Structure as a relationship in the empirical sense is not commonly reported in the literature. However, some studies about leadership and organisational structure have been carried out. A previous study posited that conditions of leadership are affected by the stability of and causal relationships among the various variables that describe the organisational structure (Meyer, 1975). Within an organisational structure, leadership is always known to have the capability to affect the people within it (M. Lee, 2007).

Leadership effect on WMIS for Water Management Decision-Making is supported in the water management literature. Grigg (2011) assert that leadership is required to address institutional challenges that occur in water resources management as technical methods alone are insufficient. There is the continuous need to use WMIS for water resources management in the decision-making process and the role of leadership in a paramount one (Abdullaev & Rakhmatullaev, 2014).

Environment

The operational definition of Environment in this study was given as the degree to which users perceive internal and external elements and the perceived desirable service qualities influence on WMIS use. Environment affected WMIS for water management Operations with a small size effect. It did not affect Structure or WMIS for Water Management Decision-Making.

Environment was operationalised through four items, ET_1 to ET_4, with all loading strongly on the construct. The first item, ET_1, was aimed at understanding how the internal environment element like financing affects the use of the WMIS. This was relevant as limited number of licenses for the software systems restricted its use in some designations. Item ET_2 sort to understand the importance of the expected and desired outcomes of the external environment to the various functions and roles within the water management organisation. The findings then showed that external environmental factors like the expected and desired outcomes affect the water management organisational functions. For example, DWS has oversight and monitoring mandate over the CMAs, and hence the activities within the WMOs must align with mandates outlined. Again, take another external environment element like the South African National Standards (SANS), they have strict water quality standards, SANS 241, that have to be adhered to (Hodgson & Manus, 2006). Aside from the SANS requirements, there are other standards such as the ISO/IEC 17025 which is critical for quality control (Broodryk & De Beer, 2004). These external environmental factors that combine the capacities of different water stakeholders affect water management operations. Thus, the use of the WMIS use is affected. In the South African context, external bodies such as the Department of Water and Sanitation (DWS), Department of Health (DoH), South African Local Government Association (SALGA), Water Research Commission (WRC), Water Services Authority (WSA) and host of other institutions all play an important role in the outcomes. The desired outcomes of being able to say monitor WSAs mean that, there should be the availability of relevant information to do so.

The item ET_3 also loaded high on the construct. It sought to find out how WMIS users willingness to help, share skills and knowledge surrounding the WMIS helps the overall environment and outcomes. The result then suggested that when they help each other, share relevant expertise and knowledge; it impacts the environment of the water management organisation which subsequently affects the success outcome of WMIS use for water management operations. The last item, ET_4, was then to understand how working together on tasks has a bearing on the success outcome of the WMIS. The finding again showed that working on tasks positively impacts success outcome of WMIS for water management operations.

Environment's effect on WMIS for Water Management Operations in this study is in line with literature in another study (Erlirianto et al., 2015) albeit the authors of that study reported a large effect size on net benefits whiles this study found a small effect size.

Thus, both internal environmental factors within water management organisations and elements and institutions external to the organisation, play an important role in the success of WMIS for operations.

Structure

The operational definition of Structure was given as the user's perception of how the organisation's structure facilitates the use of the WMIS for tasks and processes in this study. Here, operational variables like communication, integration between departments, goals and strategy, and infrastructure were used to examine the effect of organisation on the overall success of WMIS. Though all the items loaded high on the construct, it was however not found to have a significant positive effect on Environment and the outcome constructs, WMIS for Water Management Operations and WMIS for Water Management Decision-Making in the water resources management context. Some conclusions can be drawn here. The WMIS Users used the system for their respective tasks and duties regardless of what structures were in place. Again, they possibly did not find the variables within the structure construct to affect their use of the system either.

RQ2: What System Factors Determine the Success of Water Management Information Systems?

Discussion of the findings of five system constructs – WMIS System Quality, WMIS Information Quality, Service Quality, System Use, and User Satisfaction – relating to the implemented WMIS and its effect on the WMIS success outcome are presented.

WMIS System Quality

WMIS System Quality was operationally defined as the quality of the desirable characteristics and functionality of the WMIS. The model had five operationalised items (WSQ_1 – WSQ_5). The result showed that WMIS System Quality had a significant positive effect on System Use.

The findings suggested that when the WMIS is easy to learn in terms of the functionalities required for the functions and responsibilities in the water management organisations, and users consider the system easy to use, it will affect the use of system positively and that also affects its success. Also, when the functionalities and features of the WMIS are deemed to be useful for their duties and tasks, it is secure and efficient, it leads to the success of the WMIS use for operations and decision-making processes. This aligns with studies in the water management literature. This assertion is consistent with research on WMIS implementation for water resources management. Souza et al. (2009) implemented a successful WMIS for WSAs in South Africa and attributed the successful outcome of the implementation in part to the quality of the WMIS – ease of use, reliability, security and robustness. Again, in the lessons learnt from the implementation of a DSSs for water resources management in Africa, one of the first and valuable lessons learnt was that the flexibility and user-friendliness or ease of use of the system is very important. These system quality attributes were critical in the overall decision-making outcome (Giupponi & Sgobbi, 2013). Indeed, this study has just confirmed that assertion. Fundamentally, operations and decision-making in everyday water resources management rely on tools, information and knowledge borne out of quality implemented WMIS (Giupponi & Sgobbi, 2013; Rossouw et al., 2005). Thus, WMISs within the water management organisations that are easy to use or user-friendly, easy to learn, possesses the needed functionality for the tasks and duties, and considered secure will lead to the use of the system for water management tasks and decision-making.

In summary, the results show that the quality of the WMIS affects the use of the system which affects the success outcomes related to water management outcomes – operations and decision-making.

WMIS Information Quality

In this study, the operational definition of WMIS Information Quality was given as the quality of the desirable characteristics of the information obtained from the WMIS. WMIS Information Quality was operationalised with five items that addressed the accuracy, standards, reliability, traceability and accessibility. The findings showed a positive effect of WMIS information quality on system use. These items loaded strongly on the construct.

This suggested that ensuring the accuracy of the data entered for functions at the various levels of water management, is regarded as critical. Measures or mechanisms will thus have to be put in place by stakeholders within water management organisations to ensure that the accuracy of the data entered is correct or there are means to raise the necessary flags when the need arises. Additionally, the second item which speaks to standards means that the standards of information and report output must be adhered to. In the same vein, the information provided by the WMIS for functions must be reliable. Another important item characteristic is the traceability of the information in the WMIS. Stakeholders and users alike believe that there is always the need to know who entered or modified what data, and there must always be a means to have such information readily available. Above all, WMIS information must be easily accessible at all times when required. All these items load highly on the construct which affects the success outcomes of the WMIS via System Use.

This reaffirms the importance of water information and the quality of such information to water resources management (Abdullaev & Rakhmatullaev, 2014). In essence, the management and decision-making outcomes in water resources management are dependent on information and the information quality – accuracy, standards, reliability, traceability and accessibility – are critical. The results go to show that decision-making outcomes are dependent on the quality of the information and that the stakeholders and users who rely on these systems perceive its positive effect when the information quality is substantial.

Service Quality

Service Quality was operationally defined as the perception of the WMIS users on the quality of support received from both internal IS department and external consultants who provide IT services to the department. The construct was operationalised via five items to determine the perception of the WMIS users. By far, the construct had the most effect on any construct. It had a positive effect on User Satisfaction with a large effect size (β = 0,80, $p < 0{,}001$, t–value = 20,95), which subsequently had an effect on WMIS for Water Management Operations with a large effect size (β = 0,69, $p < 0{,}001$, t–value = 16,10).

This suggested that when system administrators were available to attend to the needs of users or challenges that arise, there was high satisfaction among the users. The support of the system administrators influences the satisfaction of the users. The result further showed, based on the item operationalisation of the construct, that response time in attending to user issues, the dependability of the systems administrator and willingness to always address user challenges was essential in how the users perceived the quality of service provided. Further, the users believed that the sincerity with which the administrator/facilitator handle challenges is important to them. For instance, if resolving a system challenge will take time and affect their duties, the administrator should be clear upfront. Also, the administrators should always be willing to help WMIS users. The users perceive this as an important aspect that affects their satisfaction with the use of the system.

Another revelation that came out of the study seems to support claims made by some users that, the availability of system administrators onsite was very helpful. They acknowledge that it makes resolving the problems easier when they arise since the system administrators sometimes even personally came to their desk to have a first glance at what the problem was. In the past, the system administrators claimed they had external consultants who had to come through and address challenges they sometimes face after very lengthy and unfruitful attempts on the telephone. Not only was this extremely expensive to the water department, but it also affected the satisfaction users obtained from using the system.

In summary, the effect of Service Quality on User Satisfaction is critical, and stakeholders in at the various levels of water management must consider the available support when there is the need to implement a new WMIS.

System Use

The operational definition of System Use was given as the degree in which users utilise the WMIS capabilities, the expectations and ability to use. System Use had a positive significant effect on both success outcomes – WMIS for Water Management Decision-Making and Water Management for Operations. The construct was operationalised via four items which had to do with the use of the system for tasks and daily duties, possession of the relevant skill to use the WMIS, motivation to continue using the WMIS for designated tasks and duties, and ability to be able to use the required functions of the WMIS for the designated tasks and duties.

The findings then suggests that, when WMIS users have the relevant skills required for the use of the WMIS, and the WMIS has requisite functionality needed for the job designations which they have the relevant skill and knowledge to use, and are motivated to use the system, they will use the system for tasks and duties that enhance operations and decision-making.

Though the effects of this construct on WMO and WDM have not been studied previously, its effect on net benefits have been studied in the IS literature. The results have been mixed. Whereas Alshibly (2014) and Wang and Liao (2006) reported a significant positive effect of system use on net benefits with large effect size, the study by Erlirianto et al. (2015) did not find a significant positive effect of the relationship.

Succinctly, System Use effect on WMIS for Water Management Decision-Making and WMIS for Water Management Operations particularly is relevant and consistent with other studies.

User Satisfaction

User Satisfaction was operationally defined in this study as the satisfaction level of WMIS users about the duties, available functionalities and overall usefulness. It had a significant positive effect on the success outcome construct WMIS for Water Management with large effect size (β = 0,69, $p < 0{,}001$, t–value = 16,10). The operationalisation of the construct was done using five items that sought the perception of the users of how the WMIS makes it easy for them to perform their tasks and duties, how useful it is to their designations, satisfaction with the available WMIS functionalities, satisfaction with the information timeliness and their over satisfaction.

The findings suggest that as far as the users are concerned, the WMIS should make it easy for them to undertake their duties where the system is used for such purpose. Also, the usefulness of the system and the timeliness of the information requested should be satisfactory. Additionally, if the WMIS users are satisfied with the functionalities available to them for their task, they are then satisfied overall with the WMIS system which then affects the successful outcome of its use for operational duties. As corroborated by studies in the water management literature, functionality is key to the success of WMIS implementations (Mysiak et al., 2005; Souza et al., 2009)

The findings were also consistent with other IS studies. Ghobakhloo et al. (2011) found user satisfaction to have a significant positive effect on organisational impact with a large size effect. Similarly, Wang and Liao (2006) reported a significant positive effect of user satisfaction on perceived net benefits with a large size effect.

7.3 WMIS FOR WATER MANAGEMENT OPERATIONS AND WMIS FOR WATER MANAGEMENT DECISION-MAKING AS OUTCOME VARIABLES

WMIS for Water Management Operations and WMIS for Water Management Decision-Making were the two success outcome constructs in the study. WMIS for Water Management Operations was operationally defined as the degree to which the WMIS use supports daily water management operations for efficient water management, and WMIS for Water Management Decision-Making was operationally defined as the degree to which the WMIS supports decision-making at all levels of water management and how the information enhances knowledge products, policy, and legislation.

A total of 53,4% of the variance in WMIS for Water Management Operations was explained by System Use, User Satisfaction, and Environment constructs. Also, a total of 11,6% of the variance in WMIS for Water Management Decision-Making was explained by Leadership and System Use. For WMIS for Water Management Operations, three operationalised items remained in the final model and these items loaded highly on the construct. These items were WWMO_1, WWMO_2, and WWMO_3 with the questions: "The WMIS supports operational duties of the water management process (E.g. Enhancing the water quality monitoring process, water demand management, asset management and others)"; "The WMIS aids operational duties that promote integrated water management"; and "The WMIS enhances infrastructure planning." This indicated that when the WMIS is used, they are in part used to support operational duties of water management which at the same time promotes integrated water resources management. Further, the use the WMIS enhances infrastructure planning as the system provides up-to-date information on the present infrastructure within the catchment area.

For WMIS for Water Management Decision-Making, the final model had all five items used for operationalisation. Again, the items loaded highly in this construct.

The findings suggest that WMIS should support the decision making associated with functions and roles within the various designations in the water management organisation. Also, the information output should enhance productions of reports documents and other knowledge product; decisions on policy, legislation and regulation such as the blue and green drop; aid water management decision making outcomes like water quality, water demand, and infrastructure planning; and improve the overall quality of the water management decision-making process. This in part ensures the continual use of the WMIS which affects the success thereof.

7.4 COMPARING THE EFFECTS OF THE ORGANISATIONAL AND SYSTEMS FACTORS ON WMIS FOR WATER MANAGEMENT OPERATIONS AND WMIS FOR WATER MANAGEMENT DECISION-MAKING

This section provides a summary of the discussions in Sections 7.1 – 7.3 and the results in Section 6.4.2 by comparing the effects of the organisational and system factors on the success outcomes – WMIS for Water Management Operations and WMIS for Decision-Making.

For the system factors, Service Quality had the most effect on WMIS for Water Management Operations whiles WMIS Information Quality had the most effect on WMIS for Water Management Decision-Making. WMIS System Quality also had close an effect as WMIS Information Quality on WMIS for Water Management Decision-Making but not as much. The effects WMIS Information Quality and WMIS System Quality had on Water Management Decision-Making was via another system factor. The indication here is that the information quality and system quality perception held by users and water management stakeholders contributes to the use of the system for water management decision-making. Service Quality, however, did not have a significant enough effect, indirectly, on WMIS for Water Management Decision-Making. There was no direct hypothesised relationship established between WMIS System Quality and WMIS for Water Management Decision-Making. The strong effect Service Quality had on WMIS for Water Management Operations was via User Satisfaction. Again, this then indicates that when WMIS users within the water department are satisfied with the Service Quality provided by the organisation, this flows into the inhibited use of the WMIS for Water Management Operations. Subsequently, the overall benefit of efficiency and effectiveness in water resources management by the use of ICTs as tools is achieved.

Also, System Use had a direct effect on both WMIS for Water Management Operations and WMIS for Water Management Decision-Making. However, System Use had a better effect on WMIS for Water Management Decision-Making (medium) than on WMIS for Water Management Operations (small to medium). By far, User Satisfaction had the strongest direct effect on WMIS for Water Management Operations (large). The direct effect size on WMIS for Water Management Decision-Making was large. The indication here is that the quality of both the information and system affects the system use which also affects the two success outcomes. Further, the quality of services provided in support of the WMIS by the water management organisations has a direct bearing user satisfaction levels which then affects the success of the WMIS regarding its use for water management operations.

For the organisational factors, Leadership had the strongest direct effect on WMIS for Water Management Decision-Making whereas Environment had the strongest direct effect on WMIS for Water Management Operations. The effect size of

Leadership on WDM was small, and that of Environment on WMIS for Water Management Operations was also small. Leadership had a medium effect size on fellow organisation dimension member Structure. However, this effect did not impact both WMIS for Water Management Decision-Making and WMIS for Water Management Operations directly. Also, Environment did not have any direct effect on WMIS for Water Management Decision-Making. The indication here is that the support provided by leaders' affects the success of the WMIS in its use for water management decision-making as well as the organisation's structure. More importantly, the exhibition of both transactional and transformational leadership characteristics is critical in this respect as already discussed. Further, the indication from the effect of environment on WMIS for water management operations is that both internal and external environmental factors actors like the DWS regulatory conditions, SANAS/ISO 17025 water quality monitoring standards, WRC, IMESA, DOH and others directly affects the water management operations outcomes.

In conclusion, the organisational and system factors in the model explained both the success of WMIS via the two outcome variables – WMIS Water Management Operations and WMIS for Water Management Decision-Making. The dominant constructs from these three dimensions better explained WMIS for Water Management Operations than WMIS for Water Management Decision-Making.

7.5 IMPLICATIONS OF THE STUDY

This section discusses the implication regarding its theoretical contributions and to water resources management practice.

7.5.1 Theoretical Contributions

Theoretically, a model for explanation and prediction has been provided by developing an integrated model for WMIS Success. A model to explain and predict

WMIS success has developed and empirically tested for the first time in the IS literature. Based on the principles of Integrated Water Resources Management (IWRM), theories on leadership and its application to water resources management, and an integrated IS success model – the HOT-Fit framework – which derives from the updated DeLone and McLean IS success model and the IT-Organisation fit model, this study proposed a new Water Management Information Systems Success Model (WSM) to explain WMIS success. The success of the WMIS is measured using two outcome variables – WMIS for Water Management Operations and WMIS for Water Management Decision-Making – which is based on the devolution of the IWRM principles. This makes it novel, and hence it constitutes the major theoretical contribution of the research.

The model consisted of organisational and system factors and outcome variables with operational definitions provided for this study. The operational definitions came from the IS and water management literature. The organisational aspect consisted of Leadership, Structure, and Environment; the system aspect consisted of WMIS System Quality, WMIS Information Quality, and Service Quality; the WMIS success outcomes were WMIS for Decision-Making and WMIS for Water Management Operations. The model was empirically tested in the water resources management context.

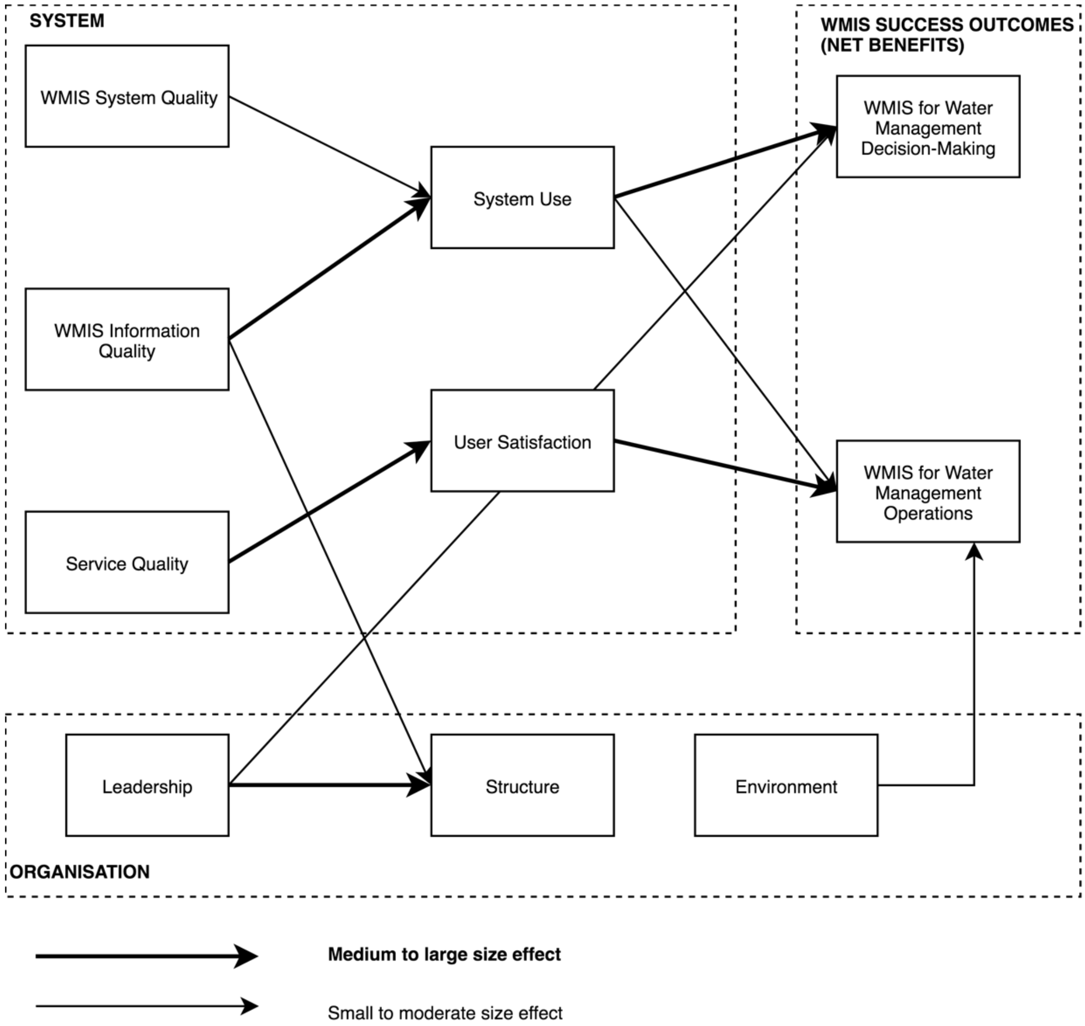

Figure 7-2: WMIS Success Model

The findings suggest a model fit of the proposed WSM model and explain the effect of the system and organisational factors on the WMIS success. To the author's best knowledge, this is the first study to develop a WMIS success model, and empirically test it in the water resources management.

7.5.2 Contribution to Water Resource Management (Practical Implications)

Practically, the proposed model offers water managers and respective stakeholders at all levels in water management organisations, knowledge of factors which contribute to the success of WMIS implementation. According to the model proposed in this study, two aspects have to be considered in a successful implementation of WMIS: System and Organisational. The analysis suggests that managers should pay attention to some system and organisational factors to ensure its success, mainly Service Quality, WMIS System Quality, WMIS Information Quality, User Satisfaction, Leadership and Environment.

Service quality had a strong influence on user satisfaction meaning the satisfaction with the WMIS was affected by the quality of service provided when users of the WMIS encountered challenges. The study found that when there were system administrators to attended to system issues when they arise, users are highly satisfied. Particularly, what the research uncovered was that users preferred IT personnel or system administrators available within the structures of the water management organisation, that is onsite. This ensures that system troubles are addressed on time as users get frustrated and unhappy with the least problem that could affect their workflow and process and in the end the efficiency of the organisation. User Satisfaction is important in the use of the WMIS for water management operations. The strong effect of user satisfaction implied that the efficiency of water management operations and processes is dependent on how satisfied users are.

Also, water managers must ensure the quality of the WMIS and information thereof. The findings suggest that the system must be regarded as easy to use. They should be able to easily locate functions and features needed for their job description, be secure and efficient. Regarding the information, accuracy should be ensured and, more particularly, mechanisms should be put in place to flag or provide warnings. Standards that are part of the external environment like ISO 17025 must be ensured to meet requirements for report generation and other outputs.

Another critical consideration is water management organisation leadership. Leadership must ensure that the appropriate structures are maintained and the necessary support, regarding the WMIS, is available when needed. The findings further suggest that leadership must follow-up on tasks to guarantee there are no errors as this has a direct bearing on the decision-making process. They also want to have leaders who recognise and commend them when they produce work that positively affects the decision-making outcomes. That means, they should act in ways that provide levels of perceived transformational and transactional leadership. Transformation leadership require behaviours that inspire efforts of individuals, making followers aware of organisational goals and outcomes and working for the organisation. This study thus recommends that water managers take notice of that. There were also aspects of transactional leadership that were brought to bear in this study. There is a sense of members wanting to be acknowledged and recognised by superiors and the management in general. The research has shown that this also goes to help the organisation. A mix of transformational and transactional leadership behaviour should be practised within the water management organisation for effective leadership.

As Environment has a direct effect on WMIS for Water Management Operations, the leadership within the water management organisations must pay continuous attention to tasks and operations that adhere to these standards and other external institutional requirements. This also implies that leadership must be regularly updated with the various standards and institutional requirements to keep the integrity of the system, information and overall water management operations outcomes successful.

7.6 LIMITATIONS OF THE RESEARCH

To begin with, this study was carried out in Cape Town, South Africa and so a few limitations arise concerning the participants, the approach that is taken, and the types of WMIS.

Cape Town which forms part of the City of Cape Town metropolitan municipality and the capital of the Western Cape Province can be considered a more "ideal" setting in respect of structures, systems and capacity. Though attempts were made to capture some commonly found WMISs in the South African water departments, there are a lot more which are contextual to different municipalities and on the larger provincial – 9 provinces in total – scale. Other systems were not used in the study.

Again, the City of Cape Town might be considered to have ample capacity and skill compared to less urban settings. There is a shortage of the pool of skilled workers particularly in the water sector in South Africa (Moodley, 2014; Tancott, 2014) and most of them are found in the big metropolis like Cape Town. Aside skill, infrastructure and unavailability of the WMISs, in general, could affect the perception and opinions of the participants.

Further, the study acknowledges that because it was cross-sectional, the empirical data collected from the questionnaire are prone to biases – non-response. Those who did not take part in the study could differ from those who participated. However, this study has performed both non-response and common-method bias tests to ensure it does not affect the present study.

7.7 SUGGESTION FOR FURTHER STUDY

The research has developed and validated a model for WMIS success and findings have been presented. The findings and limitations have presented the opportunity for suggestions for further study in the area. The subsections that follow discuss these suggestions.

Approach to the Study

The approach to this study was quantitative with empirical data collected via means of a survey questionnaire over a cross-sectional timeframe. This was informed by constraints of time, participant availability and finance. A qualitative study that engages the users can be undertaken to get other deeper insights which might not have been captured in this study. Thus, combining both approaches could help deepen understanding, and that could provide broad practical implication for the various stakeholders within the water management organisations.

Extending Study to Include Other Municipalities

The present study as discussed was undertaken in Cape Town which is urban and has "ideal" situations in respect of skills in the water department, infrastructure and other aspects. Extending the study to other municipalities will provide different insights into some of the dimensions. For example, in many municipalities that do not have IT personnel or system administrators who support WMIS users, it will be interesting to see their opinions and perceptions on aspects like System Quality, User Satisfaction, and the overall outcome of the model. Undertaking further research could provide insights that will be relevant to how we understand the various dimensions and constructs.

Using Unique WMISs for the Study

Part of the limitations was the fact that there were varying WMISs in the same study. As discussed, opinions and perceptions about varying systems in the same study are likely to have an effect on the outcomes of the various dimensions and constructs particularly on constructs like Service Quality, System Quality, and User Satisfaction. It is suggested that one possibility for future studies is to look at the WMISs regarding functionality. It is surmised that this could affect the relationships that have been established in the study.

Develop Research Instrument Further

In light of the results presented in Section 6.4.2.9, though the variance explained passed the Falk and Miller (1992) threshold for each of the R^2 values, the operationalisation of the WMIS for Water Management Decision-Making construct should be explored further. As discussed in limitation in Sections 0 and 0, if the study area is expanded (sample size) to include other municipalities, the WMIS for Water Management Decision-Making construct can be operationalised to represent the particular WMIS as suggested earlier. This means the operationalisation will be tailored more to the WMIS understudy. For example, a WMIS for river-basin management or catchments tends to serve a different purpose than a WMIS for say, asset management. The belief is that this could strengthen the WMIS for Water Management Decision-Making construct.

7.8 RESEARCH CONCLUSIONS

This research proposed an integrated model, WSM, to explain WMIS success in water resources management. The model provided factors, system and organisational, affecting the success of WMIS implementations. A thorough discussion of this model as applied to water resources management has been presented. In light of this, the implications of the study – theoretical and practical contributions – are also provided. Limitations of the study are presented with suggestions made for further research.

REFERENCES

Abdullaev, I., & Mollinga, P. P. (2010). The Socio-Technical Aspects of Water Management: Emerging Trends at Grass Roots Level in Uzbekistan. *Water*, *2*, 85–100. https://doi.org/10.3390/w2010085

Abdullaev, I., & Rakhmatullaev, S. (2014). Data Management for Integrated Water Resources Management in Central Asia. *Journal of Hydroinformatics*, *16*(6), 1425–1440. https://doi.org/10.2166/hydro.2014.097

Agyenim, J. B., & Gupta, J. (2012). IWRM and Developing Countries: Implementation challenges in Ghana. *Physics and Chemistry of the Earth*, *47–48*, 46–57. https://doi.org/10.1016/j.pce.2011.06.007

Aher, P. D., Adinarayana, J., Gorantiwar, S. D., & Sawant, S. A. (2014). *Information System for Integrated Watershed Management Using Remote Sensing and GIS*. (P. . Srivastava, S. Mukherjee, M. Gupta, & T. Islam, Eds.) (Remote Sen). Switzerland: Springer International. https://doi.org/10.1007/978-3-319-05906-8

Ajzen, I., & Fishbein, M. A. (1975). *Belief , attitude , intention and behaviour : An introduction to theory and research*. Addison-Wesley.

Akhmouch, A. (2012). *Water Governance in Latin America and the Caribbean: A Multi-Level Approach* (OECD Regional Development Working Papers No. 2012/04). https://doi.org/http://dx.doi.org/10.1787/5k9crzqk3ttj-en OECD

Akter, S., Ray, P., & D'Ambra, J. (2011). Viewing systems as services: the role of service quality. *Icis*, 1–18. Retrieved from http://ro.uow.edu.au/commpapers/3125/

Al-Mamary, Y. H., Shamsuddin, A., & Aziati, N. (2013). The Impact of Management Information Systems Adoption in Managerial Decision Making : *Management Information Systems*, *8*(4), 010–017.

Alavi, M., & Carlson, P. (1992). A Review of MIS Research and Disciplinary Development. *Journal of Management Information Systems*, *8*(4), 45–62. https://doi.org/10.2753/JEI0021-3624440403

Ali, N. (2012). *Knowledge Management Systems Success Model for Healthcare*. Massey University. Retrieved from http://mro.massey.ac.nz/bitstream/handle/10179/5862/02_whole.pdf?sequence=2&isAllowed=y

AlKhatib, H. (2013). *E - Government Systems Success and User Acceptance in Developing Countries: The Role of Perceived Support Quality*. Brunel University.

Alreemy, Z., Chang, V., Walters, R., & Wills, G. (2016). Critical Success Factors (CSFs) for Information Technology Governance (ITG). *International Journal of Information Management*, *36*(6), 907–916.

https://doi.org/10.1016/j.ijinfomgt.2016.05.017

Alshibly, H. H. (2014). Evaluating E-HRM success : A Validation of the Information Systems Success Model. *International Journal of Human Resource Studies*, *4*(3), 107–124. https://doi.org/10.5296/ijhrs.v4i3.5929

Anderson, A., Karar, E., & Farolfi, S. (2009). Synthesis: IWRM lessons for implementation. *Water SA*, *34*(6), 665–670.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Antonakis, J., Avolio, B. J., & Sivasubramaniam, N. (2003). *Context and Leadership: An Examination of the Nine-Factor Full-Range Leadership Theory Using the Multifactor Leadership Questionnaire. Leadership Quarterly* (Vol. 14). https://doi.org/10.1016/S1048-9843(03)00030-4

Anzaldi, G., Rubion, E., Corchero, A., Sanfeliu, R., Domingo, X., Pijuan, J., & Tersa, F. (2014). Towards an Enhanced Knowledge-based Decision Support System (DSS) for Integrated Water Resource Management (IWRM). *Procedia Engineering*, *89*, 1097–1104. https://doi.org/10.1016/j.proeng.2014.11.230

Arsene, C. T. C., Gabrys, B., & Al-Dabass, D. (2012). Decision support system for water distribution systems based on neural networks and graphs theory for leakage detection. *Expert Systems with Applications*, *39*(18), 13214–13224. https://doi.org/10.1016/j.eswa.2012.05.080

Asit. (2008). Integrated water resources management: Is it working? *International Journal of Water Resources Development*, *24*(1), 5–22. https://doi.org/10.1080/07900620701871718

Avolio, B., Bass, B., & Jung, D. (1999). Re-Examining the Components of Transformational and Transactional Leadership using the Multifactor Leadership Questionnaire. *Journal of Occupational and Organizational Psychology Bass & Avolio Van Muijen & Koopman House & PodsakoV*, *72*, 441–462. https://doi.org/10.1348/096317999166789

Avolio, B., Walumbwa, F., & Weber, T. J. (2009). *Leadership : Current Theories , Research , and Future Directions Future Directions* (No. Paper 37). *Management Department Faculty Publications.* https://doi.org/10.1146/annurev.psych.60.110707.163621

Ayre, C., & Scally, A. J. (2014). Critical values for Lawshe's content validity ratio: Revisiting the original methods of calculation. *Measurement & Evaluation in Counseling & Development (Sage Publications Inc.)*, *47*(1), 79–86. https://doi.org/10.1177/0748175613513808

Babalhavaeji, F., & Farhadpoor, M. R. (2011). Academic Libraries ' External

Environment and Environmental Scanning by Managers*. *BİLGİ DÜNYASI*, *12*(2), 280–294.

Badjana, H. M., Zander, F., Kralisch, S., Helmschrot, J., & Flügel, W. (2015). An Information System for Integrated Land and Water Resources Management the Kara River Basin (Togo and Benin). *International Journal of Database Management Systems*, *7*(1), 15–27.

Bailey, J. E., & Pearson, S. W. (1983). Development of a Tool for Measuring and Analyzing Computer User Satisfaction Author (s): James E . Bailey and Sammy W . Pearson Published by : INFORMS Stable URL : http://www.jstor.org/stable/2631354 REFERENCES Linked references are available on JSTOR f. *Management Science*, *29*(5), 530–545.

Baisch, J. (2009). Data shortage in Africa. *Desalination*, *248*(1–3), 524–529. https://doi.org/10.1016/j.desal.2008.05.097

Balfour, F., Badenhorst, H., & Trollip, D. (2011). *A Gap Analysis of Water Testing Laboratories in South Africa*. Water Research Commission (South Africa).

Balsam, G. (2016). *Decision Support Systems for Water Management: Investigating Stakeholder Perceptions of System Use*. University of South Florida. Retrieved from http://scholarcommons.usf.edu/etd/6176

Baroudi, J. J., & Orlikowski, W. J. (1987). A Short Form Measure of User Information Satisfaction: A Psychometric Evaluation and Notes on Use. *Journal of Management Information Systems*, *4*(4), 44–59. https://doi.org/10.1080/07421222.1988.11517807

Barzekar, H., & Karami, M. (2014). Organizational Factors that Affect the Implementation of Information Technology : Perspectives of Middle Managers in Iran. *Acta Inform Med.*, *22*(July), 325–328. https://doi.org/10.5455/aim.2014.22.325-328

Bass, B. M., & Avolio, B. J. (1996). The Transformational and Transactional Leadership of Men and Women. *Applied Psychology*, *45*(1), 5–34.

Battaglia, M. P. (2011). *Nonprobability Sampling*. (P. J. Lavrakas, Ed.). Sage Publications Inc. https://doi.org/10.4135/9781412963947.n337

Baumüller, M. (2007). *Managing Cultural Diversity: An Empirical Examination of Cultural Networks and Organizational Structures as Governance Mechanisms in Multinational Corporations*. Sage Publications Ltd.

Becker, J., & Niehaves, B. (2007). Epistemological Perspectives on IS research: A Framework for Analysing and Systematizing Epistemological Assumptions. *Information Systems Journal*, *17*(2), 197–214. https://doi.org/10.1111/j.1365-2575.2007.00234.x

Blaikie, N. (2000). *Designing Social Research The Logic of Anticipation.pdf*. Blackwell

Scientific Publications.

Bokhari, R. H. (2005). The relationship between system usage and user satisfaction: a meta-analysis. *Journal of Enterprise Information Management*, *18*(2), 211–234. https://doi.org/10.1108/17410390510579927

Borchardt, D., Bogardi, J. J., & Ibisch, R. B. (2016). *Integrated Water Resources Management*. (D. Borchardt, J. J. Bogardi, & R. B. I. Editors, Eds.). Springer International Publish AG Switzerland.

Boudreau, M.-C., Gefen, D., & Straub, D. W. (2001). Validation in Information Systems Research: a State-of-the-Art Assessment. *MIS Quarterly*, *25*(1), 1–16. https://doi.org/10.2307/3250956

Bouranta, N., Chitiris, L., & Paravantis, J. (2009). The relationship between internal and external service quality. *International Journal of Contemporary Hospitality Management*, *21*(3), 275–293. https://doi.org/10.1108/09596110910948297

Bourblanc, M., & Blanchon, D. (2014). The Challenges of Rescaling South African Water Resources Management: Catchment Management Agencies and Interbasin Transfers. *Journal of Hydrology*, *519*(PC), 2381–2391. https://doi.org/10.1016/j.jhydrol.2013.08.001

Bracht, M. J. Van. (1995). Geohydrological Information Systems for Water Management. *Water Science and Technology*, *31*(8), 353–356. https://doi.org/10.1016/0273-1223(95)00387-3

Broodryk, G., & De Beer, W. (2004). A Benchmarking Study on Information Management Systems for Water Laboratories in South Africa. *Water SA*, *29*(1), 39–42. https://doi.org/10.4314/wsa.v29i1.4944

Brown, D., Marsden, G., & Rivett, U. (2012). WATER alert!: using mobile phones to improve community perspective on drinking water quality in South Africa. *ICTD '12 Proceedings of the Fifth International Conference on Information and Communication Technologies and Development*. Retrieved from http://dl.acm.org/citation.cfm?id=2160703

Bureau of Meteorology. (2016). *Improving Water Information Programme Progress Report: Advances in water information made by the Bureau of Meteorology in 2015*.

Burns, J. M. (1978). *Leadership*. New York: Harper & Row.

Burton-Jones, A. (2005). *New perspectives on the system usage construct. CIS Dissertations*. Georgia State University.

Burton-Jones, A., Mclean, E. R., & Monod, E. (2011). *On Approaches to Building Theories: Process, Variance and Systems*.

Buruncuk, G., & Gülser, Z. G. (2004). Factors Affecting Implementation of

Information Systems Success and Failure. *Management Information System Istanbul*, 1–11.

Butterworth, J., Warner, J., Moriarty, P., Smits, S., & Batchelor, C. (2010). Finding practical approaches to integrated water resources management. *Water Alternatives*, *3*(1), 68–81.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and Discriminant Validation by the Multitrait-Multimethod Matrix. *Psychological Bulletin*, *56*(2).

Caniëls, M. C. J., & Bakens, R. J. J. M. (2012). The effects of Project Management Information Systems on decision making in a multi project environment. *International Journal of Project Management*, *30*(2), 162–175. https://doi.org/10.1016/j.ijproman.2011.05.005

Carley, K. M. (1991). Designing Organizational Structures to Cope with Communication Breakdowns: A Simulation Model. *Industrial Crisis Quarterly*, *5*, 19–57.

Chao, L., Hui, Z., & Xiaofeng, Z. (2015). Data Quality Assessment in Hydrological Information Systems. *Journal of Hydroinformatics*, *17*(4), 640–661. https://doi.org/10.2166/hydro.2015.042

Chen, H.-J. (2010). Linking Employees' e-Learning System Use to their Overall Job Outcomes : An Empirical Study Based on the IS Success Model. *Computers & Education*, *55*(4), 1628–1639. https://doi.org/10.1016/j.compedu.2010.07.005

Chen, S. (2006). Leadership Styles and Organization Structural Configurations. *The Journal of Human Resource and Adult Learning*, (November), 39–46. Retrieved from https://ucbachelor.ducere.edu.au/pluginfile.php/9099/mod_resource/content/4/ Leadership Styles and Organization Structural Configurations.pdf

Chen, W., & Hirschheim, R. (2004). A Paradigmatic and Methodological Examination of Information Systems Research from 1991 to 2001. *European Journal of Information Systems*, 197–235.

Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. In G. A. Marcoulides (Ed.), *Modern Methods for Business Research* (pp. 295–336). New Jersey and London: Lawrence Erlbaum Associates. https://doi.org/10.1016/j.aap.2008.12.010

Cho, J., & Michel, J. W. (2011). How Does Leadership Affect Information Systems Success ? The Role of Transformational Leadership How Does Leadership Affect Information Systems Success ? The Role of Transformational Leadership, 1–26.

Cho, J., Park, I., & Michel, J. W. (2011). How Does Leadership Affect Information Systems Success? The Role of Rransformational Leadership. *Information and*

Management, *48*(7), 270–277. https://doi.org/10.1016/j.im.2011.07.003

Choi, W., Rho, M. J., Park, J., Kim, K.-J., Kwon, Y. D., & Choi, I. Y. (2013). Information System Success Model for Customer Relationship Management System in Health Promotion Centers. *Healthcare Informatics Research*, *19*(2), 110–20. https://doi.org/10.4258/hir.2013.19.2.110

Choo, W. C. (1995). Information management and intelligent organizations.pdf. In *Digital Libraries Conference* (pp. 81–99). Retrieved from http://choo.ischool.utoronto.ca/FIS/respub/DLC95.pdf

Chua, W. F. (1986). Radical Developments in Accounting Thought. *The Accounting Review*, *61*(4), 601–632. https://doi.org/10.2307/247360

Chumney, F. L. (2013). Structural Equation Models With Small Samples : A Comparative Study of Four Approaches, 146.

Churchil Jr., G. A. (1979). A Paradigm for Developing Better Measures of Marketing Constructs. *Journal of Marketing Research*, *16*(Feb), 64–73. https://doi.org/10.1017/CBO9781107415324.004

Claassen, M. (2013). Integrated Water Resources Management in South Africa. *International Journal of Water Governance*, 323–338. https://doi.org/10.7564/13-IJWG12

Clifford, E., Coakley, D., Curry, E., Degeler, V., Costa, A., Messervey, T., … Smit, S. (2014). Interactive Water Services: The WATERNOMICS Approach. In *16th Conference on Water Distribution System Analysis, WDSA 2014 An* (Vol. 89, pp. 1058–1065). Elsevier. https://doi.org/10.1016/j.proeng.2014.11.225

CoCT. (2016). *Annual Water Services Development Plan Performance and Water Services Audit Report.* Cape Town, South Africa.

CoCT. (2017). City of Cape Town: Water Services Development Plan - IDP Water Sector Input Report. *City of Cape Town.* Retrieved from http://resource.capetown.gov.za/documentcentre/Documents/City strategies, plans and frameworks/Water Services Development Plan.pdf

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). New York, New York, USA: Lawrence Erlbaum Associates.

Cosgrove, W. J., & Loucks, D. P. (2015). Water Management: Current and Future Challenges and Research Directions. *Water Resources Research*, *51*, 4823–4839. https://doi.org/10.1002/2014WR016869.Received

Cresswell, K. M., Bates, D. W., & Sheikh, A. (2013). Ten key considerations for the successful implementation and adoption of large-scale health information technology. *Journal of American Medical Informatics Association*, *20*(1), 9–13. https://doi.org/10.1136/amiajnl-2013-001684

CSIR. (2010). *A CSIR Perspective on Water in South Africa.* Retrieved from http://www.csir.co.za/nre/docs/CSIR Perspective on Water_2010.PDF

Curry, E., Degeler, V., Clifford, E., Coakley, D., Costa, A., van Andel, S. J., ... Smit, S. (2014). Linked Water Data for Water Information Management. In B. Brodaric & M. Piasecki (Eds.), *11th International Conference on Hydroinformatics (HIC).*

Cyert, R. M., & March, J. G. (1963). A behavioral theory of the firm. Prentice Hall. https://doi.org/10.2307/2228147

Davis, F., Bagozzi, R., & Warshaw, P. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003.

Davis, J., Crow, B., & Miles, J. (2012). Measuring water collection times in Kenyan informal settlements. *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development - ICTD '12*, 114. https://doi.org/10.1145/2160673.2160689

Delden, H. Van, Seppelt, R., White, R., & Jakeman, A. J. (2011). A Methodology for the Design and Development of Integrated Models for Policy Support. *Environmental Modelling and Software*, *26*(3), 266–279. https://doi.org/10.1016/j.envsoft.2010.03.021

DeLone, W., & McLean, E. (1992). Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research*, *3*(1), 60–95. https://doi.org/10.1287/isre.3.1.60

DeLone, W., & McLean, E. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems*, *19*(4), 9–30. https://doi.org/10.1073/pnas.0914199107

Dent, M. (2010). The Role of Information Systems Management in the Management of Water. In B. Schreiner & R. Hassan (Eds.), *Transforming Water Management in South Africa: Designing and Implementing a New Policy Framework* (pp. 215–235). Heidelberg London New York: Springer. Retrieved from http://books.google.com/books?hl=en&lr=&id=at5YTatyMncC&oi=fnd&pg=PR5&dq=Transforming+Water+Management+in+South+Africa+designing+and+implementing+a+new+policy+framework&ots=Jr8TElOKlq&sig=f8qSCFpWQcTxJz717CdrFdyskZo

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method.* Hoboken, New Jersey: Wiley.

Dishaw, M., Strong, D., Bandy, D. B., Dishaw, M. T., & Strong, D. M. (2002). Extending the Task-Technology Fit Model with Self-Efficacy Constructs. In *AMCIS 2002 Proceedings.* Retrieved from http://aisel.aisnet.org/amcis2002%0Ahttp://aisel.aisnet.org/amcis2002/143

Doherty, N. F., Champion, D., & Wang, L. (2010). An Holistic Approach to Understanding the Changing Nature of Organisational Structure. *Information Technology & People*, *23*(2), 116–135. https://doi.org/10.1108/09593841011052138

Doll, W. J., & Torkzadeh, G. (1988). End-User Computing. *MIS Quarterly*, *12*(2), 259–274.

Doll, W. J., & Torkzadeh, G. (1998). Developing a multidimensional measure of system-use in an organizational context. *Information & Management*, *33*(4), 171–185. https://doi.org/10.1016/S0378-7206(98)00028-7

Dubé, L., & Paré, G. (2003). Rigor in Information Systems Positivist Case Research: Current Practices, Trends, and Recommendations. *MIS Quarterly*, *27*(4), 597–636.

Duncan, R. B. (1972). Characteristics of Organizational Environments and Perceived Environmental Uncertainty. *Administrative Science Quarterly*, *17*(3), 313–327. https://doi.org/10.2307/2392145

Dussault, M., Frenette, É., & Fernet, C. (2013). Leadership: Validation of a Self-Report Scale. *Psychological Reports*, *112*(2), 419–436. https://doi.org/10.2466/01.08.PR0.112.2.419-436

DWA. (2007). *Introduction and Orientation: Guidelines for the Development of Catchment Management Strategies in South Africa.* Pretoria.

DWA. (2013). *National Water Resource Strategy: Water for an Equitable and Sustainable Future.* (2nd ed.). Pretoria.

DWAF. (1997). *White Paper on a National Water Policy for South Africa.* Retrieved from http://www.dwaf.gov.za/Documents/Policies/nwpwp.pdf

DWAF. (2001). *Monitoring and assessment information systems - MAIS Phase 3.*

DWAF. (2005a). *Water and Sanitation Business: The Roles and Responsibilities of Local Government and Related Institutions.* Department of Water Affairs and Forestry.

DWAF. (2005b). Water Management Institutions: Overview.

DWS. (2010). *An Introduction to the Electronic Water Quality Management System.*

DWS. (2014). *The Blue Drop and No Drop Handbook.* Pretoria, South Africa: Department of Water and Sanitation. Retrieved from https://www.dwa.gov.za/dir_ws/dwqr/subscr/ViewComDoc.asp?Docid=604

DWS. (2015). *Development of a National Integrated Water Information System (NIWIS) WP10722.* Pretoria, South Africa. Retrieved from http://niwis.dwa.gov.za//UserFiles/niwis/html/Public_P3C2_IMP2_NIWIS_Use r_Manual.pdf

EEA. (2014). *Public participation: contributing to better water management.* Copenhagen, Denmark.

Ein-dor, P., & Segev, E. (1978). Organizational Context and the Success of Management Information Systems. *Management Science*, *24*(10), 1064–1077.

Ejere, E. I., & Abasilim, U. D. (2013). Impact of Transactional and Transformational Leadership Styles on Organisational Performance : Empirical Evidence from Nigeria. *The Journal of Commerce*, *5*(1), 30–41.

Eludoyin, O. (2007). Challenges of River Basin information System (RBIS) as a framework for the assessment and monitoring of surface water in Nigeria. In *International Symposium on New Directions in Urban Water Management.*

EOH. (2015a). IMQS Solutions: Asset Management. Retrieved from http://www.imqs.co.za/wp-content/uploads/2015/09/IMQS-Solution-Module-Asset-Management.pdf

EOH. (2015b). IMQS Solutions: Water. EOH. Retrieved from http://www.imqs.co.za/wp-content/uploads/2015/09/IMQS-Solution-Module-Asset-Management.pdf

Erlirianto, L. M., Ali, A. H. N., & Herdiyanti, A. (2015). The Implementation of the Human , Organization , and Technology – Fit (HOT – Fit) Framework to Evaluate the Electronic Medical Record (EMR) System in a Hospital. *Procedia - Procedia Computer Science*, *72*, 580–587. https://doi.org/10.1016/j.procs.2015.12.166

Fair, K. A., & Compion, J. K. (2008). The Water Distribution System Master Planning Process in South Africa with a Focus on Metered Demand-, Water Loss Monitoring-, Calibration - and Financial Analysis. In J. E. Van Zyl, A. A. Ilemobade, & H. . Jacobs (Eds.), *Proceedings of the 10th Annual Water Distribution Systems Analysis Conference (WDSA)* (pp. 47–56). ASCE.

Falissard, B. (2012). *Analysis of Questionnaire Data with R. International Statistical Review.* Boca Raton, FL: CRC Press. https://doi.org/10.1111/j.1751-5823.2012.00196_5.x

Falk, R. F., & Miller, N. B. (1992). *A Primer for Soft Modeling* (1st Editio). Akron, Ohio: The University of Akron Press.

Farrell, A. M. (2010). Insufficient discriminant validity: A comment on Bove, Pervan, Beatty, and Shiu (2009). *Journal of Business Research*, *63*(3), 324–327. https://doi.org/10.1016/j.jbusres.2009.05.003

Fitzgerald, G., & Russo, N. L. (2005). The turnaround of the London Ambulance Service Computer-Aided Despatch system (LASCAD). *European Journal of Information Systems*, *14*(May 2004), 244–257.

https://doi.org/10.1057/palgrave.ejis.3000541

Fölster, J., Johnson, R. K., Futter, M. N., & Wilander, A. (2014). The Swedish monitoring of surface waters: 50 years of adaptive monitoring. *Ambio*, *43*(1), 3–18. https://doi.org/10.1007/s13280-014-0558-z

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39. https://doi.org/10.2307/3151312

Freitas, A. (2013). *Water as a stress factor in sub-Saharan Africa -. Briefs*. Retrieved from http://www.iss.europa.eu/uploads/media/Brief_12.pdf

Fulazzaky, M. A., & Akil, H. (2009). Development of data and information centre system to improve water resources management in Indonesia. *Water Resources Management*, *23*(6), 1055–1066. https://doi.org/10.1007/s11269-008-9314-0

Funke, N., Oelofse, S., Hattingh, J., Ashton, P., & Turton, A. (2007). IWRM in Developing Countries: Lessons from the Mhlatuze Catchment in South Africa. *CSIR-Natural Resources and the Environment*, *32*, 9. https://doi.org/10.1016/j.pce.2007.07.018

Gable, G. G. (1994). Integrating Case Study and Survey Research Methods: An Example in Information Systems. *European Journal of Information Systems*, *3*(2), 112–126.

Gable, G. G., Sedera, D., & Chan, T. (2003). Enterprise Systems Success: A Measurement Model. *International Conference on Information Systems*, 576–591. https://doi.org/doi=10.1.1.95.2176&rep=rep1&type=pdf

Gable, G. G., Sedera, D., & Chan, T. (2008). Information Systems Re-conceptualizing Information System Success : The IS-Impact Measurement Model * Re-conceptualizing Information System Success : The IS-Impact Measurement Model. *Journal of the Association for Information Systems*, *9*(7), 377–408.

Galliers, R. D. (1991). *Choosing Appropriate Information Systems Research Approaches: A revised taxonomy.*

Gefen, D., Straub, D., & Boudreau, M.-C. (2000). Structural Equation Modeling and Regression : Guidelines for Research Practice. *Communications of the Association for Information Systems*, *4*(October), 7. https://doi.org/10.1.1.25.781

Georgakakos, A. P. (2006). Decision Support Systems for Water Resources Management: Nile Basin Applications and further Needs.

Gerlak, A. K., Lautze, J., & Giordano, M. (2011). *Water resources data and information exchange in transboundary water treaties. International Environmental Agreements: Politics, Law and Economics* (Vol. 11). https://doi.org/10.1007/s10784-010-9144-4

GGA. (2016a). *Government Performance in South Africa 2016 What the people really think : GGA National Government Survey*. Retrieved from http://www.gga.org/wp-content/uploads/2016/04/English-summary.pdf

GGA. (2016b, April). Africa in Fact. *Special Focus - South Africa*, (April), 63–113.

Ghobakhloo, M., Arias-Aranda, D., & Benitez-Amado, J. (2011). Information technology implementation success within SMEs in developing countries: An interactive model. In *POM 22nd Annual Conference: Operations Management - The Enabling Link* (p. 63). Reno, Nevada. Retrieved from http://iucontent.iu.edu.sa/Scholars/Information Technology/Information technology implementation success within SMEs in developing countries An interactive model.pdf

Gichoya, D. (2005). Successful implementation of ICT projects in government. In *Proceedings of the European Conference on e-Government, ECEG* (pp. 171–182).

Giupponi, C. (2007). Decision Support Systems for implementing the European Water Framework Directive: The MULINO approach. *Environmental Modelling and Software*, *22*(2), 248–258. https://doi.org/10.1016/j.envsoft.2005.07.024

Giupponi, C., & Sgobbi, A. (2013). Decision Support Systems for Water Resources Management in Developing Countries: Learning from Experiences in Africa. *Water*, *5*(2), 798–818. https://doi.org/10.3390/w5020798

GLS Consulting. (2017). GLS Software. Retrieved July 27, 2017, from http://wadiso.com/services/technology.html

Goodall, J. L., Horsburgh, J. S., Whiteaker, T. L., Maidment, D. R., & Zaslavsky, I. (2008). A first approach to web services for the National Water Information System. *Environmental Modelling and Software*, *23*(4), 404–411. https://doi.org/10.1016/j.envsoft.2007.01.005

Goodhue, D. (1995). Understanding User Evaluations of Information Systems. *Management Science*, *41*(12), 1827–1844. https://doi.org/10.1287/mnsc.41.12.1827

Goodhue, D., Lewis, W., & Thompson, R. (2007). Statistical Power in Analyzing Interaction Effects : Questioning the Advantage of PLS with Product Indicators. *Information Systems Research*, *18*(2), 211–227. https://doi.org/10.1287/isre.1070.0123

Goodhue, D., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, *19*(2), 213.

Gorla, N., Somers, T. M., & Wong, B. (2010). Organizational Impact of System Quality , Information Quality , and Service Quality. *Journal of Strategic Information Systems*, *19*(3), 207–228. https://doi.org/10.1016/j.jsis.2010.05.001

Gourbesville, P. (2008). Integrated River Basin Management , ICT and DSS :

Challenges and Needs. *Physics and Chemistry of the Earth*, *33*, 312–321. https://doi.org/10.1016/j.pce.2008.02.007

Gourbesville, P. (2011). ICT for Water Efficiency. *Environmental Monitoring*, 411–426.

Gourbesville, P., Du, M., Zavattero, E., & Ma, Q. (2016). DSS Architecture For Water Uses Management. *Procedia Engineering*, *154*, 928–935. https://doi.org/10.1016/j.proeng.2016.07.512

Gray, D. (2009). *Doing Research in the Real World*. London: Sage Publications.

Gray, D. (2013). *Doing Research in the Real World. Doing Research in the Real World.* Sage. https://doi.org/10.1017/CBO9781107415324.004

Gregor, S. (2002). A Theory of Theories in Information Systems. *Information Systems Foundations*, 1–18.

Gregor, S. (2006). The Nature of Theory in Information Systems. *MIS Quarterly*, *30*(3), 611–642. https://doi.org/10.1080/0268396022000017725

Grigg, N. S. (2008a). Integrated Water Resources Management : Balancing Views and Improving Practice. *Water International*, *33*(3), 279–292. https://doi.org/10.1080/02508060802272820

Grigg, N. S. (2008b). *Total Water Management: Practices for a Sustainable Future*. American Water Works Association.

Grigg, N. S. (2011). Leadership for Sustainable Water Management: Challenges and Opportunities. *ASCE*, *11*(2), 121–127.

Grigg, N. S. (2016). *Integrated Water Resource Management: An Interdisciplinary Approach*. Palgrave Macmillan.

Guba, E. G., & Lincoln, Y. S. (1994). Competing Paradigms in Qualitative Research. *Handbook of Qualitative Research*, 105–117. https://doi.org/http://www.uncg.edu/hdf/facultystaff/Tudge/Guba%20&%20Lincoln%201994.pdf

Gumbo, B., Juizo, D., & van der Zaag, P. (2003). Information is a prerequisite for water demand management: Experiences from four cities in Southern Africa. *Physics and Chemistry of the Earth*, *28*(20–27), 827–837. https://doi.org/10.1016/j.pce.2003.08.010

Gunasekaran, A. (2006). Information Technology and Systems Justification : A Review for Research and Applications. *European Journal of Operational Research*, *173*, 957–983. https://doi.org/10.1016/j.ejor.2005.06.002

Hair, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Long Range Planning* (Vol.

46). https://doi.org/10.1016/j.lrp.2013.01.002

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *The Journal of Marketing Theory and Practice*, *19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM) - An emerging tool in business research. *European Business Review*, *26*(2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, *40*(3), 414–433. https://doi.org/10.1007/s11747-011-0261-6

Halawi, L. A., McCarthy, R. V, & Aronson, J. E. (2008). An Empirical Investigation of Knowledge Management Systems' Success. *Journal of Computer Information Systems*, *48*(2), 121–135. https://doi.org/10.3122/jabfm.2010.06.100075

Harris, J., Howman, A., Grobler, D., Kühn, A., & Ntsaba, M. (2001). Information Systems for Water Resources Monitoring and Assessment. In *10th South African national Hydrology Symposium* (pp. 26–28).

Hellstén, S.-M., & Markova, M. (2006). The DeLone and McLean Model of Information Systems Success – Original and Updated Models. *SIGCHI 2006 Proceedings*, *19*(4), 1–5. https://doi.org/10.1007/978-1-4419-6108-2

Henseler, J. (2010). On the Convergence of the Partial Least Squares Path Modeling Algorithm. *Computational Statistics*, *25*(1), 107–120. https://doi.org/10.1007/s00180-009-0164-x

Henseler, J., Ringle, C. M., & Sarstedt, M. (2014). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The Use of Partial Least Squares Path Modeling in International Marketing. In R. R. Sinkovics & P. N. Ghauri (Eds.), *New Challenges to International Marketing (Advances in International Marketing)* (Vol. 20, pp. 277–319). Emerald Group Publishing Limited. https://doi.org/10.1016/0167-8116(92)90003-4

Herbertson, P. W., & Tate, E. L. (2001). *Tools for water use and demand managment in South Africa. Technical Reports in Hydrology and Water Resources*. Geneva, Switzerland. Retrieved from http://www.wmo.int/pages/prog/hwrp/documents/TD73.pdf

Hering, J. G., & Ingold, K. M. (2012). Water Resources Management: What Should

Be Integrated? *Science*, *336*, 1234–1235. https://doi.org/10.1126/science.1218230

Hirschheim, R. A. (1992). Information Systems Epistemology: an Historical Perspective. In *Information Systems Research: Issues, Methods and Practical Guidelines* (pp. 28–60). Oxford: Blackwell Scientific Publications.

Hodgson, K., & Manus, L. (2006). A Drinking Water Quality Framework for South Africa. *WaterSA*, *32*(5), 673–678. Retrieved from http://www.ajol.info/index.php/wsa/article/view/47853/34223

Hooper, B. P. (2003). Integrated Water Resources Management and River Basin Governance, (1963).

Horne, J. (2015). Water Information as a Tool to Enhance Sustainable Water Management—The Australian Experience. *Water*, *7*, 2161. https://doi.org/10.3390/w7052161

Hou, C.-K. (2012). Examining the effect of user satisfaction on system usage and individual performance with business intelligence systems: An empirical study of Taiwan's electronics industry. *International Journal of Information Management*, *32*(6), 560–573. https://doi.org/10.1016/j.ijinfomgt.2012.03.001

Hu, X.-J., Xiong, Y.-C., Li, Y.-J., Wang, J.-X., Li, F.-M., Wang, H.-Y., & Li, L.-L. (2014). Integrated water resources management and water users' associations in the arid region of northwest China: a case study of farmers' perceptions. *Journal of Environmental Management*, *145*, 162–9. https://doi.org/10.1016/j.jenvman.2014.06.018

Hussein, R., Selamat, M. H., Anom, R. B., Karim, N. S. A., & Mamat, A. (2005). The Impact of Organizational Factors on Information Systems Success: An Empirical Investigation in the Malaysian Electronic-Government Agencies, (1), 1–16.

Igbaria, M., & Tan, M. (1997). The consequences of information technology acceptance on subsequent individual performance. *Information & Management*, *32*(3), 113–121. https://doi.org/10.1016/S0378-7206(97)00006-2

Iivari, J. (2005). An Empirical Test of the Model of Information System Success. *The DATA BASE for Advances in Information Systems*, *36*(2), 8–27. https://doi.org/10.1145/1066149.1066152

Irani, Z., & Love, P. (2008). *Evaluating Information Systems Public and Private Sector*. Elsevier.

Ives, B., Olson, M. H., & Baroudi, J. J. (1983). The Measurement of User lnformation Satisfaction. *Communications of the ACM*, *26*, 785–793. https://doi.org/10.1145/358413.358430

Jacobs, H. (2008). Residential water information management. *SA Journal of Information Management*, *10*(3). https://doi.org/10.4102/sajim.v10i3.327

Jacobs, H., & Fair, K. (2012). A Tool to Increase Information-Processing Capacity for Consumer Water Meter Data. *SA Journal of Information Management*, *14*(1), 7 pp. DOI: 10.4102/sajim.v14i1.500. https://doi.org/10.4102/sajim.v14i1.500

Jiang, J. J., Klein, G., Parolia, N., & Li, Y. (2012). An Analysis of Three SERVQUAL Variations in Measuring Information System Service Quality. *The Electronic Journal Information Systems Evaluation*, *15*(2), 149–162. https://doi.org/10.2307/4132324

Johnson, E. (2003). Integrated Water Asset Management System (IWAMS). *Water Science and Technology: Water Supply*, *3*(1–2), 111–117.

Jonker, L. (2007). Integrated water resources management : The theory – praxis – nexus , a South African perspective, *32*, 1257–1263. https://doi.org/10.1016/j.pce.2007.07.031

Jöreskog, K. G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, *34*(2), 183–202. https://doi.org/10.1007/BF02289343

Junier, S., & Mostert, E. (2014). A Decision Support System for the Implementation of the Water Framework Directive in the Netherlands : Process , Validity and Useful Information. *Environmental Science and Policy*, *40*, 49–56. https://doi.org/10.1016/j.envsci.2014.04.004

Karar, E., Mazibuko, G., Gyedu-Ababio, T., & Weston, D. (2010). Catchment Management Agencies: A Case Study of Institutional Reform in South Africa. In B. Schreiner & R. Hassan (Eds.), *Transforming Water Management in South Africa: Designing and Implementing a New Policy Framework* (pp. 145–163). Heidelberg London New York.

Karodia, H., & Weston, D. (2000). South Africa's New Water Policy and Law. *Intersectoral Management of River Basins*, 13–21. Retrieved from http://www.lk.iwmi.org/pubs/Proceedings/Loskop/loskop.pdf#page=34

Karthe, D., Hofmann, J., Ibisch, R., Heldt, S., Westphal, K., Menzel, L., … Malsy, M. (2015). Science-based IWRM implementation in a data-scarce central Asian region: Experiences from a research and development project in the Kharaa River Basin, Mongolia. *Water (Switzerland)*, *7*(7), 3486–3514. https://doi.org/10.3390/w7073486

Kaushal, S. (2011). Effect of leadership and organizational culture on information technology effectiveness: A review. *2011 International Conference on Research and Innovation in Information Systems, ICRIIS'11*. https://doi.org/10.1109/ICRIIS.2011.6125668

Ke, W., & Wei, K. K. (2008). Organizational Culture and Leadership in ERP Implementation. *Decision Support Systems*, *45*, 208–218.

Kelly, R. A. (2015). Using Decision Support for Water Quality Improvement Planning: the CAPER DSS. In *21st International Congress on Modelling and Simulation* (pp. 2262–2268). Gold Coast, Australia.

Kettinger, W., & Lee, C. (1994). Perceived Service Quality and User Satisfaction with the Information Services Function. *Decision Sciences*, *25*(5–6), 737–766.

Khudhair, R. S. (2016). An Empirical Test of Information System Success Model in a University's Electronic Services. *Advances in Natural and Applied Sciences*, *10*(12), 54–62.

Kim, Y., & Lee, H. S. (2014). Quality, perceived usefulness, user satisfaction, and intention to use: An empirical study of ubiquitous personal robot service. *Asian Social Science*, *10*(11), 1–16. https://doi.org/10.5539/ass.v10n11p1

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy*, *65*(23), 2276–2284. https://doi.org/10.2146/ajhp070364

Koh, C. E., Prybutok, V. R., Ryan, S. D., & Wu, Y. (2010). A model for mandatory use of software technologies: An integrative Approach by applying multiple levels of abstraction of information science. *Informing Science: The International Journal of an Emerging Transdiscipline, 13.*

Kossieris, P., Panayiotakis, A., Tzouka, K., Gerakopoulou, P., & Rozos, E. (2014). An eLearning approach for improving household water efficiency. In *16th Conference on Water Distribution System Analysis, WDSA 2014 An* (Vol. 00, pp. 1–7).

Kouroupetroglou, C., Slooten, J. V. A. N., Clifford, E., Coakley, D., Curry, E., Smit, S., & Perfido, D. (2015). WATERNOMICS: Serving diverge user needs under a single water information platform. *E-Proceedings of the 36th IAHR World Congress*, (1), 1–12.

Kulkarni, U. R., Ravindran, S., & Freeze, R. (2006). A Knowledge Management Success Model: Theoretical Development and Empirical Validation. *Journal of Management Information Systems*, *23*(3), 309–347. https://doi.org/10.2753/MIS0742-122223031

Kumpel, E., Peletz, R., Bonham, M., Fay, A., & Cock-Esteb, A. (2015). When Are Mobile Phones Useful for Water Quality Data Collection? An Analysis of Data Flows and ICT Applications among Regulated Monitoring Institutions in Sub-Saharan Africa, 10846–10860. https://doi.org/10.3390/ijerph120910846

Labadie, J. W. (2006). MODSIM: Decision Support System for Integrated River Basin Management. *Summit on Environmental Modelling and Software the International Environmental Modelling and Software Society*, 1518–1524. Retrieved from http://www.iemss.org/iemss2006/papers/w5/MODSIMpaper.pdf

Lai, T. L. (2004). Service quality and perceived value's impact on satisfaction, intention and usage of short message service (SMS). *Information Systems Frontiers*, *6*(4), 353–368. https://doi.org/10.1023/B:ISFI.0000046377.32617.3d

Landrum, H., Prybutok, V., Zhang, X., & Peak, D. (2009). Measuring IS System Service Quality with SERVQUAL: Users' Perceptions of Relative Importance of the Five SERVPERF Dimensions. *Informing Science: The International Journal of an Emerging Transdiscipline*, *12*, 17–35. https://doi.org/10.1145/2038056.2038060

Lawshe, C. (1975). A Quantitative Approach to Content Validy. *Personnel Psychology*, *28*(1), 563–575. https://doi.org/10.1111/j.1744-6570.1975.tb01393.x

Lee, A. (1991). Integrating Positivist and Interpretive Approaches to Organizational Research. *INFORMS*, *2*(4), 342–365.

Lee, G.-G., Lin, H.-F., & Pai, J.-C. (2005). Influence of Environmental and Organizational Factors on the Success of Internet-Based Interorganizational Systems Planning. *Internet Research*, *15*(5), 527–543. https://doi.org/10.1108/10662240510629466

Lee, M. (2007). A Study on Relationship among Leadership , Organizational Culture , the Operation of Learning Organization and Employees' Job Satisfaction. *The Learning Organization*, *14*(2), 155–185. https://doi.org/10.1108/09696470710727014

Lee, S.-K., & Yu, J.-H. (2012). Success model of project management information system in construction. *Automation in Construction*, *25*, 82–93. https://doi.org/10.1016/j.autcon.2012.04.015

Leedy, P. D., & Ormrod, J. E. (2013). *Practical Research: planning and design* (10th Editi). Pearson.

Lehr, J. (2005). *Water Encyclopedia: Domestic, Municipal, Industrial Water Supply and Waste Disposal.* John Wiley & Sons Inc.

Lewis, B. R., Snyder, C. A., & R. Kelly, R. J. (1995). An empirical assessment of the information resource management construct. *Journal of Management Information Systems*, *12*(1), 199–223. https://doi.org/10.1080/07421222.1995.11518075

Lewis, B. R., Templeton, G. F., & Byrd, T. A. (2005). A Methodology for Construct Development in MIS Research. *European Journal of Information Systems*, *14*, 388–400. https://doi.org/10.1057/palgrave.ejis.3000552

Lincklaen, W. T., Wehn, U., & Montalvo, D. (2013). Exploring Water Leadership. *Water Policy*, *15*, 15–41. https://doi.org/10.2166/wp.2013.010

Lindfors, H. (2011). *Drinking Water Quality Monitoring and Communication in Rural South Africa.* Chalmers University of Technology. Retrieved from http://publications.lib.chalmers.se/records/fulltext/146362.pdf

Liu, L., Li, C., & Zhu, D. (2012). A New Approach to Testing Nomological Validity and Its Application to a Second-Order Measurement Model of Trust. *Journal of the Association for Information Systems*, *13*(12), 950–975. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=15369323&AN=87717509&h=0aUNenbq3cypYtforOvPO7MKzMfeUihmnpMkvPHROPX9ZjVBpwwQM3Y+CYcEKby/m0mqram8ZTTfPFpA863VJQ==&crl=c

Lohmöller, J.-B. (1989). *Latent Variable Path Modeling with Partial Least Squares* (Vol. 1). Springer-Verlag Berlin Heidelberg GmbH. https://doi.org/10.1017/CBO9781107415324.004

Loucks, D. P. (2000). Sustainable Water Resources Management. *Water International*, *25*(1), 3–10. https://doi.org/10.1080/02508060008686793

Lu, H.-P., Yu, H.-J., & Lu, S. S. K. (2001). The Effects of Cognitive Style and Model Type on DSS Acceptance: An Empirical Study. *European Journal of Operational Research*, *131*.

Lucas Jr., H. C., & Olson, M. (1994). The Impact of Information Technology on Organizational Flexibility. *Journal of Organizational Computing & Electronic Commerce*, *4*, 155–177.

Magiera, E., Jach, T., & Kurcius, L. (2017). Tips Service and Water Diary An Innovative Decision Support System for the Efficient Water. In *Intelligent Decision Technologies* (pp. 273–280). Springer International Publish AG Switzerland. https://doi.org/10.1007/978-3-319-59421-7

Malhotra, N. K., Kim, S. S., & Patil, A. (2006). Common Method Variance in IS Research: A Comparison of Alternative Approaches and a Reanalysis of Past Research. *Management Science*, *52*(12), 1865–1883. https://doi.org/10.1287/mnsc.1060.0597

Malone, T. W. (1986). A Formal Model of Organizational Structure and Its Use in Predicting Effects of Information Technology. *Working Paper*, (August), 1–58.

Mason, R. O. (1978). Measuring Information Output: A Communication Systems Approach. *Information & Management*, *1*(4), 219–234. https://doi.org/https://doi.org/10.1016/0378-7206(78)90028-9

McCartney, M. P. (2007). *Decision Support Systems for Large Dam Planning and Operation in Africa* (No. 119).

McDonnell, R. A. (2008). Challenges for Integrated Water Resources Management: How Do We Provide the Knowledge to Support Truly Integrated Thinking? *International Journal of Water Resources Development*, *24*(February 2015), 131–143. https://doi.org/10.1080/07900620701723240

Medema, W., Mcintosh, B. S. B. B. S., & Jeffrey, P. J. P. (2008). From Premise to

Practice: A Critical Assessment of Integrated Water Resources Management and Adaptive Management Approaches in the Water Sector. *Ecology And Society*, *13*(2), 29. https://doi.org/29

Meissner, R., Stuart-Hill, S., & Nakhooda, Z. (2017). The Establishment of Catchment Management Agencies in South Africa with Reference to the Flussgebietsgemeinschaft Elbe: Some Practical Considerations. In E. Karar (Ed.), *Freshwater Governance for the 21st Century* (pp. 15–28). Springer International Publishing.

Memon, A. H., & Rahman, I. A. (2014). SEM-PLS analysis of inhibiting factors of cost performance for large construction projects in malaysia: Perspective of clients and consultants. *The Scientific World Journal*, *2014*. https://doi.org/10.1155/2014/165158

Messervey, T., Perfido, D., Hannon, L., & Smit, S. (2015). Standards-based methodology for the design and implementation of a water management system. In *2nd International Electronic Conference on Sensors and Applications* (p. 6).

Meyer, M. W. (1975). Leadership and Organizational Structure. *American Journal of Sociology*, *81*(3), 514–542.

Miller, R. C., Guertin, D. P., & Heilman, P. (2004). Information Technology in Watershed Management Decision Making. *Journal of the American Water Resources Association*, *85719*, 347–358.

Mingers, J. (2003). The Paucity of Multimethod Research: A Review of the Information Systems Literature. *Information Systems Journal*, *13*, 233–249.

Mirmasoudi, A., Farjami, Y., & Pourebrahimi, A. (2012). The Effect of IT on Organizational Structure (Case study: Refah bank in Guilan). *International Journal of …*, *1*(2), 48–54. Retrieved from http://www.ijissm.org/?_action=articleInfo&article=2568&vol=188

Molobela, I. P., & Sinha, P. (2011). Management of water resources in South Africa: A review. *African Journal of Environmental Science and Technology*, *5*(12), 993–1002. https://doi.org/10.5897/AJEST11.136

Monecke, A., & Leisch, F. (2012). semPLS: Structural Equation Modeling Using Partial Least Squares. *Journal of Statistical Software*, *48*(3), 1–32. https://doi.org/http://dx.doi.org/10.18637/jss.v048.i03

Mongi, H., Meinhardt, M., & Africa, S. (2016). Integrated ICTs for Water Basins Management in Southern Africa: Systematic Review and Meta-analyses for Perceived Relevance Criteria. *Agris On-Line Papers in Economics and Informatics*, *VIII*(2), 103–110. https://doi.org/10.7160/aol.2016.080208.Introduction

Moodley, S. (2014, April). Skills Drought Taking its Toll on SA Water Sector. Retrieved July 22, 2017, from http://www.engineeringnews.co.za/article/inadequate-skills-base-creating-skills-shortage-in-water-sector-2014-04-25/rep_id:4136

Moore, M. L. (2013). Perspectives of complexity in water governance: Local experiences of global trends. *Water Alternatives*, *6*(3), 487–505.

Morales, G. M.-A. (2011). Partial Least Squares (PLS) Methods: Origins, Evolution, and Application to Social Sciences. *Communications in Statistics - Theory and Methods*, *40*(13), 2305–2317. https://doi.org/10.1080/03610921003778225

Mouton, J. (1996). *Understanding Social Research* (1st Editio). Hatfield, Pretoria: Van Schaik.

Movik, S., Mehta, L., van Koppen, B., & Denby, K. (2016). Emergence , Interpretations and Translations of IWRM in South Africa. *Water Alternatives*, *9*(3), 456–472.

Myers, M. (1997). Qualitative Research in Information Systems. *MIS Quarterly*, *21*(2), 241–242. Retrieved from http://www.misq.org/supplements/

Myers, M., & David, A. (2002). *Qualitative Research in Information Systems*. Sage Publications Ltd.

Myers, M., & Liu, F. (2009). What Does the Best Is Research Look Like? an Analysis of the Ais Basket of Top Journals. *PACIS 2009 Proceedings*, Paper 61.

Mysiak, J., Giupponi, C., & Rosato, P. (2005). Towards the Development of a Decision Support System for Water Resource Management. *Environmental Modelling & Software*, *20*(2), 203–214. https://doi.org/10.1016/j.envsoft.2003.12.019

Nakayama, M. (2002). Power of Information Sharing for International Water Resources Management. *International Water Resources Management*. Retrieved from http://scholar.law.colorado.edu/allocating-and-managing-water-for-sustainable-future/73

Nepfumbada, M., Braune, E., & Madikizela, B. (2005). Information Needs for Integrated Water Resources Management. Department of Water Affairs and Forestry.

Newsted, P. R., Huff, S. L., & Munro, M. C. (1998). Survey Instruments in Information Systems. *MIS Quarterly*, *22*(4), 553. https://doi.org/10.2307/249555

Nilsson, S. (2003). *The Role and Use of information in Transboundary Water Management. Licenciate Thesis TRITALWR LIC*. Kungl Tekniska Högskolan.

Nsubuga, F. N. W., Namutebi, E. N., & Nsubuga-Ssenfuma, M. (2014). Water Resources of Uganda : An Assessment and Review. *Journal of Water Resource* *and Protection*, (October), 1297–1315. https://doi.org/10.4236/jwarp.2014.614120.

O'Reilly, C. A., Caldwell, D. F., Chatman, J. A., Lapiz, M., & Self, W. (2010). How leadership matters: The effects of leaders' alignment on strategy implementation. *Leadership Quarterly*, *21*(1), 104–113. https://doi.org/10.1016/j.leaqua.2009.10.008

Ojo, A. I. (2017). Validation of the DeLone and McLean Information Systems Success Model. *Healthcare Informatics Research*, *23*(1), 60–66.

Olumoye, M. Y. (2013). Impact of Information Systems on Management Decision-Making in the Nigerian Insurance Sector. *International Journal of Scientific & Technology Research*, *2*(12), 123–128.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research*, *2*(1), 1–28. https://doi.org/10.1287/isre.2.1.1

Osborne, J. W., & Overbay, A. (2004). The power of outliers (and why researchers should always check for them). *Practical Assessment, Research & Evaluation*, *9*(6), 1–8. https://doi.org/10.1017/CBO9781107415324.004

Otuke, J. O. (2016). *Role of information Communication Technologies in Water Management*. University of Nairobi. Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/97204/Otuke_Role Of Information Communication Technologies In Water Management.pdf?sequence=1&isAllowed=y

Palmius, J. (2007). Criteria for measuring and comparing information systems. *Proceedings of the 30th Information Systems Research Seminar in Scandinavia IRIS*, 1–24. Retrieved from http://www.palmius.com/joel/text/IRIS-30-final.pdf

Pereira, Â. Gg., Rinaudo, J.-D., Jeffrey, P., Blasques, J., Quintana, S. C., Courtois, N., … Petit, V. (2003). ICT Tools to Support Public Participation in Water Resources Governance & Planning : Experiences from the Design and Testing of a Multi-Media Platform. *Journal of Environmental Assessment Policy and Management*, *5*(3), 395–420.

Pérez-Mira, B. (2010). *Validity of Delone and McLean's Model of Information Systems success at the website level of analysis*. Louisiana State University. https://doi.org/10.1017/CBO9781107415324.004

Perumal, T. (2014). *Research Methodology*. Open University Malaysia. https://doi.org/http://dx.doi.org/10.5210/fm.v8i1.1023

Petter, S., DeLone, W., & McLean, E. (2008). Measuring Information Systems Success: Models, Dimensions, Measures, and Interrelationships. *European Journal of Information Systems*, *17*(3), 236–263.

https://doi.org/10.1057/ejis.2008.15

Petter, S., & McLean, E. R. (2009). A meta-analytic assessment of the DeLone and McLean IS success model: An examination of IS success at the individual level. *Information and Management*, *46*(3), 159–166. https://doi.org/10.1016/j.im.2008.12.006

Pinsonneault, A., & Kraemer, K. L. (1993). Survey Research Methodology in Management Information Systems: An Assessment. *Journal of Management Information Systems*, *10*(2), 75–105.

Pitman, W. (2011). Overview of water resource assessment in South Africa: Current state and future challenges. *Water SA*, *37*(5), 659–664. https://doi.org/10.4314/wsa.v37i5.3

Pitt, L. F., Watson, R. T., & Kavan, C. B. (1995). Service Quality : A Measure of Information Systems Effectiveness. *MIS Quarterly*, *19*(2), 173–187. Retrieved from http://www.jstor.org/stable/249687

Pitt, L. F., Watson, R. T., & Kavan, C. B. (1997). Measuring Information Systems Service Quality: Concerns for a Complete Canvas. *Misq*, *21*(2), 209. https://doi.org/10.2307/249420

Plengsaeng, B., Wehn, U., & van der Zaag, P. (2014). Data-sharing bottlenecks in transboundary integrated water resources management: a case study of the Mekong River Commission's procedures for data sharing in the Thai context. *Water International*, *39*(7), 933–951. https://doi.org/10.1080/02508060.2015.981783

Podsakoff, P. M. (1986). Self-Reports in Organizational Research: Problems and Prospects. *Journal of Management*, *12*(4), 531–544. https://doi.org/10.1177/014920638601200408

Pollard, S., & du Toit, D. (2011). Towards Adaptive Integrated Water Resources Management in Southern Africa: The Role of Self-organisation and Multi-scale Feedbacks for Learning and Responsiveness in the Letaba and Crocodile Catchments. *Water Resources Management*, *25*(15), 4019–4035. https://doi.org/10.1007/s11269-011-9904-0

Pollard, S., & Toit, D. (2008). Integrated Water Resource Management in Complex Systems : How the Catchment Management Strategies Seek to Achieve Sustainability and Equity in Water Resources in South Africa. *Water SA*, *34*(6), 671–680.

Prybutok, V. R., Zhang, X., & Ryan, S. D. (2008). Evaluating Leadership , IT Quality , and Net Benefits in an e-Government Environment, *45*, 143–152. https://doi.org/10.1016/j.im.2007.12.004

Quin, A. (2012). *Information, systems and water management : Information systems* *which support water management - cases from rural water supply in Uganda and WFD implementation in the North Baltic River Basin District, Sweden*. Royal Institute of Technology (KTH).

Qutaishat, F. T. (2013). Users ' Perceptions towards Website Quality and Its Effect on Intention to Use E-government Services in Jordan. *International Business Research*, *6*(1), 97–105. https://doi.org/10.5539/ibr.v6n1p97

Rai, A., Lang, S., & Welker, R. (2002). Assessing the Validity of IS Success Models: An Empirical Test and Theoretical Analysis. *Information Systems Research*, *13*(1), 50–69.

Ravand, H., & Baghaei, P. (2014). Partial Least Squares Structural Equation Modeling (PLS-SEM). *Practical Assessment, Research & Evaluation*, *26*(2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Raymond, L. (1990). Organizational Context and Information Systems Success : A Contingency Approach Organizational Context _ and Information Systems Success : A Contingency Approach. *Journal of Management Information Systems*, *6*(4), 5–20. https://doi.org/10.1080/07421222.1990.11517869

Reinartz, W., Haenlein, M., & Henseler, J. (2009). An empirical comparison of the efficacy of covariance-based and variance-based SEM. *International Journal of Research in Marketing*, *26*(4), 332–344. https://doi.org/10.1016/j.ijresmar.2009.08.001

Republic of South Africa. (1997). Water Services Act. *Government Gazette*. Retrieved from http://www.saflii.org/za/legis/num_act/wsa1997175.pdf

Rezaei, A., Asadi, A., Rezvanfar, A., & Hassanshahi, H. (2009). The Impact of Organizational Factors on Management Information System Success : An Investigation in the Iran ' s Agricultural Extension Providers. *International Information & Library Review*, *41*(3), 163–172. https://doi.org/10.1016/j.iilr.2009.05.002

Ringle, C. M., Wende, S., & Will, S. (2007). SmartPLS 2.0 (M3) Beta. Hamburg, Germany.: University of Hamburg.

Rivett, U. (2012). Information Systems and Water Quality Management – Reviewing the Relationship between Data Collection , Information Creation and Decision Making. *WISA*, 10. Retrieved from http://www.ewisa.co.za/literature/files/ID251 Paper318 Wilson-Jones T.pdf

Rivett, U., Champanis, M., & Wilson-Jones, T. (2013). Monitoring drinking water quality in South Africa : Designing information systems for local needs. *Water SA*, *39*(3), 409–414.

Rivett, U., Taylor, D., Chair, C., Forlee, B., Belle, J.-P. van, & Chigona, W. (2014). *Community Engagement in Drinking Water Supply Management : A Review*.

Pretoria, South Africa.

Roky, H., & Al Meriouh, Y. (2015). Evaluation by Users of an Industrial Information System (XPPS) Based on the DeLone and McLean Model for IS Success. *Procedia Economics and Finance*, *26*(0), 903–913. https://doi.org/10.1016/S2212-5671(15)00903-X

Rossouw, N., Botha, D., & Dlamini, E. (2005). A Review of a Water Quality Information Management System for a Water Management Authority in South Africa and Swaziland. *Electronic Jounral of Information Systems in Developing Countries*, *22*, 167188.

RSA. (1996). *The Constitution of the Republic of South Africa*. Republic of South Africa.

RSA. (1998a). National Water Act. *Government Gazette*. South Africa: Republic of South Africa. Retrieved from http://www.saflii.org/za/legis/num_act/wsa1997175.pdf

RSA. (1998b). *National Water Act*.

Saleth, R. M., & Dinar, A. (2005). Water institutional reforms: Theory and practice. *Water Policy*, *7*(1), 1–19.

Sanchez, A., Kappelman, L., & Prybutok, V. (2004). The Role of Organizational Leadership and IT Leadership in Achieving IS Success. In *AMCIS 2004 Proceedings*. AIS Electronic Library(AISeL).

Sanchez, G. (2013). PLS Path Modeling with R. *R Package Notes*, 235. https://doi.org/citeulike-article-id:13341888

Sauer, C., College, T., & Willcocks, L. (2003). Establishing the Business of the Future : The Role of Organizational Architecture and Information Technologies. *European Management Journal*, *21*(4), 497–508. https://doi.org/10.1016/S0263-2373(03)00078-1

Schaub-Jones, D., Souza, P. F. de, & Mackintosh, G. S. (2014). Lessons Learnt from the Implementation of ICT Applications to Support the Water Sector. In *WISA 2014* (pp. 1–16).

Scheepers, R., Scheepers, H., & Ngwenyama, O. K. (2006). Contextual Influences on User Satisfaction With Mobile Computing: Findings From Two Healthcare Organizations. *European Journal of Information Systems*, *15*(3), 261–268. https://doi.org/10.1057/palgrave.ejis.3000615

Schepers, J., Wetzels, M., & Ruyter, K. De. (2005). Leadership Styles in Technology Acceptance: Do Followers Practice What Leaders Preach? *Managing Service Quality*, *15*(6), 496–508. https://doi.org/10.1108/09604520510633998

Scott, D., & Morrison, M. (2006). *Key Ideas in Educational Research* (First).

Continuum International Publishing Group.

Seddon, P. B. (1997). A Respecification and Extension of the DeLone and McLean Model of IS Success. *Information Systems Research.* https://doi.org/10.1287/isre.8.3.240

Seddon, P. B., & Kiew, M.-Y. (1996). A Partial Test and Development of DeLone and McLean's Model of IS Success. *Australian Journal of Information Systems*, *4*(1), 90–109. https://doi.org/10.3127/ajis.v4i1.379

Selst, M. Van, & Jolicoeur, P. (1994). A Solution to the Effect of Sample Size on Outlier Elimination. *The Quarterly Journal of Experimental Psychology Section A*, *47*(3), 631–650. https://doi.org/10.1080/14640749408401131

Shanks, G. (2002). Guidelines for conducting positivist case study research in information systems. *Australasian Journal of Information Systems*, *10*(December), 76–85. https://doi.org/10.3127/ajis.v10i1.448

Shannon, C., & Weaver, W. (1949). *The Mathematical Theory of Communication* (First). Urbana: The University of Illinois Press.

Shao, Z., Feng, Y., & Hu, Q. (2012). How Leadership Styles Impact Enterprise Systems Success throughout the Lifecycle : A Theoretical Exploration. In *45th Hawaii International Conference on Systems Sciences.* https://doi.org/10.1109/HICSS.2012.303

Shim, J. P., Warkentin, M., Courtney, J. F., & Power, D. J. (2002). Past , Present , and Future of Decision Support Technology. *Decision Support Systems*, *33*, 111–126.

Siebrits, R., Winter, K., & Jacobs, I. (2014). Water Research Paradigm Shifts in South Africa. *South African Journal of Science*, *110*(5/6), 1–9. https://doi.org/10.1590/sajs.2014/20130296

Simonovic, S. P. (2009). *Managing Water Resources: Methods and Tools for a Systems Approach.* Paris, France: UNESCO.

Sivo, S. A., Saunders, C., Chang, Q., & Jiang, J. J. (2006). How Low Should You Go ? Low Response Rates and the Validity of Inference in IS Questionnaire Research. *Journal of the Association for Information Systems*, *7*(6), 351–414.

Skog, L.-M. (2009). *The success of DSS in a police organization : An evaluation study. Ratio.* Lund University. Retrieved from http://biblioteket.ehl.lu.se/olle/papers/0003430.pdf

Song, X., & Letch, N. (2012). Research on IT / IS Evaluation : A 25 Year Review. *The Electronic Journal of Information Systems Evaluation*, *15*(3), 276–287.

Sor, R. (2006). Information technology and organisational structure Vindicating theories from the past. *Management Decision*, *42*(2), 59–67. https://doi.org/10.1108/00251740410513854

Soto-Garcia, M., Del-Amor-Saavedra, P., Martin-Gorriz, B., & Martínez-Alvarez, V. (2013). The role of information and communication technologies in the modernisation of water user associations' management. *Computers and Electronics in Agriculture*, *98*, 121–130. https://doi.org/10.1016/j.compag.2013.08.005

Souza, P. F. De, Hugo, W., Wensley, A., & Kuhn, K. (2009). Electronic Water Quality Management System(eWQMS) New Developments: Use of a Systems Engineering Process to Aid Improved Data Quality Assurance/Quality Control. eWISA. Retrieved from http://www.ewisa.co.za/literature/files/191_141 De Souza.pdf

Ssemaluulu, P. (2012). *An Instrument to Assess Information Systems Success in Developing Countries.* Enschede: Ipskamp Drukkers B.V., Netherlands.

Stewart, B. (2015). Measuring what we manage – the importance of hydrological data to water resources management. *Proceedings of the International Association of Hydrological Sciences*, *366*(June 2014), 80–85. https://doi.org/10.5194/piahs-366-80-2015

Straub, D. (1989). Validating Instruments in MIS Research. *MIS Quarterly*, *13*(2), 147–169. https://doi.org/10.2307/248922

Straub, D., Boudreau, M.-C., & Gefen, D. (2004). Validation Guidelines for IS Positivist Research. *Communications of the Association for Information Systems*, *13*(24), 380–427. https://doi.org/Article

Suhardiman, D., Clement, F., & Bharati, L. (2015). Integrated water resources management in Nepal: key stakeholders' perceptions and lessons learned. *International Journal of Water Resources Development*, *31*(2), 284–300. https://doi.org/10.1080/07900627.2015.1020999

Tancott, G. (2014, May). Skills Shortages affect SA Water Sector. Retrieved July 22, 2017, from http://www.infrastructurene.ws/2014/05/05/skills-shortages-affect-sa-water-sector/

Taylor, J. (2016). Management of Australian Water Utilities : The Significance of Transactional and Transformational Leadership. *Australian Journal of Public Administration*, *76*(1), 18–32. https://doi.org/10.1111/1467-8500.12200

Tenenhaus, M., Vinzi, V. E., Chatelin, Y. M., & Lauro, C. (2005). PLS Path Modeling. *Computational Statistics and Data Analysis*, *48*(1), 159–205. https://doi.org/10.1016/j.csda.2004.03.005

Thu, H. N., & Wehn, U. (2016). Data sharing in international transboundary contexts: The Vietnamese perspective on data sharing in the Lower Mekong Basin. *Journal of Hydrology*, *536*, 351–364. https://doi.org/10.1016/j.jhydrol.2016.02.035

Timmerman, J. G. (2015). *Information Needs for Water Management.* Boca Raton, FL: Taylor & Francis Group.

Timmerman, J. G., & Langaas, S. (2005). Water information: What is it good for? the use of information in transboundary water management. *Regional Environmental Change*, *5*(4), 177–187. https://doi.org/10.1007/s10113-004-0087-6

Timmerman, J. G., Ottens, J. J., & Ward, R. C. (2000). The Information Cycle as a Framework for Defining Information Goals for Water-Quality Monitoring. *Environmental Management*, *25*(3), 229–239. https://doi.org/10.1007/s002679910018

Tolbert, P. S., & Hall, R. H. (2016). *Organizations : structures, processes, and outcomes.* Routledge.

UNEP. (1997). *Water Pollution Control - A Guide to the Use of Water Quality Management Principles.* (R. Helmer & I. Hespanhol, Eds.).

Urbach, N., & Ahlemann, F. (2010). Structural Equation Modeling in Information Systems Research Using Partial Least Squares Structural Equation Modeling in Information Systems Research Using Partial Least Squares. *Journal of Information Technology Theory and Application*, *11*(2), 5–40.

van Rooyen, J., de Lange, M., & Hassan, R. (2011). Water Resource Situation, Strategies and Allocation Regimes in South Africa. In *Transforming Water Mangement in South Africa. Designing and Implementing a New Policy Framework* (pp. 19–32). Springer. https://doi.org/10.1007/978-90-481-9367-7

Varis, O., Kummu, M., Keskinen, M., Sarkkula, J., Koponen, J., Heinonen, U., & Makkonen, K. (2006). Integrated water resources management on the Tonle Sap Lake, Cambodia. *Water Science & Technology: Water Supply*, *6*(5), 51. https://doi.org/10.2166/ws.2006.843

Varzaru, M., & Varzaru, A. (2013). Leadership style and organizational structure in the context of Mintzberg's vision. In *Proceedings of the 7th international management conference* (pp. 467–476).

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *2*(273–315), 273–315.

Venkatesh, V., & Davis, F. (2000). Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425–478.

Vinzi, V. E., Chin, W. W., Henseler, J., & Wang, H. (2010). *Handbook of Partial Least*

Squares. Methods (1 Ed.). Heidelberg: Springer-Verlag. https://doi.org/10.1007/978-3-642-16345-6

Vinzi, V. E., Trinchera, L., & Amato, S. (2010). PLS Path Modeling: From Foundations to Recent Developments and Open Issues forModel Assessment and Improvement. In *Handbook of Partial Least Squares* (pp. 47–83). https://doi.org/10.1007/978-3-540-32827-8

Visser, M., Van Biljon, J., & Herselman, M. (2013). Evaluation of management information systems: A study at a further education and training college. *SA Journal of Information Management*, *15*(1), 1–8. https://doi.org/10.4102/sajim.v15i1.531

Vlahos, G. E., Ferratt, T. W., & Knoepfle, G. (2004). The use of computer-based information systems by German managers to support decision making. *Information and Management*, *41*(6), 763–779. https://doi.org/10.1016/j.im.2003.06.003

Volk, M., Lautenbach, S., & Delden, H. Van. (2009). How Can We Make Progress with Decision Support Systems in Landscape and River Basin Management? Lessons Learned from a Comparative Analysis of Four Different Decision Support Systems. *Environmental Management*, *46*, 834–849. https://doi.org/10.1007/s00267-009-9417-2

Walsham, G. (1995). Interpretive case studies in IS research: nature and method. *European Journal of Information Systems*, *4*(2), 74–81. https://doi.org/10.1057/ejis.1995.9

Wang, Y.-S., & Liao, Y.-W. (2006). Assessing E-Government Systems Success: A Validation Of The Delone And Mclean Model Of Information Systems Success. In *Proceedings of the 11th Annual Conference of Asia Pacific Decision Sciences Institute* (pp. 356–366). Hong Kong. Retrieved from http://nuradli.com/iecons2013/4D-1.pdf

WEF. (2011). *Information Technology in Water and Wastewater Facilities*. (Water Environment Federation, Ed.). McGraw Hill.

Wegelin, W., & Jacobs, H. (2012). The development of a municipal water conservation and demand management strategy and business plan as required by the Water Services Act, South Africa. *Water SA*, *39*(3), 415–422. Retrieved from http://www.ajol.info/index.php/wsa/article/view/90169

Welle, K. (2010). *Strategic review of WaterAid ' s water point mapping in East Africa*. London.

Welling, R., Cartin, M., Baykono, D., & Diallo, O. (2012). *Volta River: Basin Ghana & Burkina Faso - Transboundary water management through multi-level participatory governance and community projects*. Retrieved from http://data.iucn.org/dbtw-wpd/edocs/2012-010.pdf

Western Cape Government. (2011). Institutional Arrangements and Operational Issues. In *Western Cape IWRM Action Plan: Status Quo*.

Wetzels, M., Odekerken-Schröder, G., & Oppen, C. Van. (2009). Assessing Using PLS Path Modeling Hierarchical and Empirical Construct Models: Guidelines. *MIS Quarterly*, *33*(1), 177–195.

WHO. (2005). *Water safety plans: Managing drinking-water quality from catchment to consumer.* Geneva, Switzerland. Retrieved from http://www.who.int/water_sanitation_health/dwq/wsp170805.pdf

Wienand, I., Nolting, U., & Kistemann, T. (2009). Using Geographical Information Systems (GIS) as an instrument of water resource management: a case study from a GIS-based Water Safety Plan in Germany. *Water Science and Technology: A Journal of the International Association on Water Pollution Research*, *60*, 1691–1699. https://doi.org/10.2166/wst.2009.501

Wirkus, L., Boge, V., Klaphake, A., Voils, O., Grossmann, M., Mostert, E., … Neubert, S. (2006). *Transboundary Water Management in Africa: Challenges for Development Cooperation.* Retrieved from http://www.die-gdi.de/CMS-Homepage/openwebcms3_e.nsf/(ynDK_contentByKey)/ENTR-7BMFGZ?Open&nav=expand:Publications;active:Publications%5CENTR-7BMFGZ

Wixom, B. H., & Todd, P. a. (2005). Integration of User Satisfaction and Technology Acceptance. *Information Systems Research*, *16*(1), 85–102. https://doi.org/10.1287/isre.l050.0042

Wold, H. (1980). Soft Modeling: Intermediate between Traditional Model Building and Data Analysis. *Mathematical Statistics*.

Wold, H. (1985). Partial Least Squares. In S. Kotz & N. . Johnson (Eds.), *Encyclopedia of Statistical Sciences, Vol. 6* (pp. 581–591). New York: John Wiley.

Wright, B. E., & Pandey, S. K. (2010). Transformational Leadership in the Public Sector: Does Structure Matter? *Journal of Public Administration and Research Theory*, *20*(1), 75–89. https://doi.org/10.1093/jopart/mup003

Wu, J. H., & Wang, Y. M. (2006). Measuring KMS success: A respecification of the DeLone and McLean's model. *Information and Management*, *43*(6), 728–739. https://doi.org/10.1016/j.im.2006.05.002

Yukl, G. (2010). *Leadership in Organizations* (Seveth Edi). Pearson.

Yusof, M. M. (2011). HOT-fit Evaluation Framework: Validation Using Case Studies and Qualitative Systematic Review in Health Information Systems Evaluation Adoption. *Proceedings of the 5th European Conference on Information Management and Evaluation*, 359–365.

Yusof, M. M., Kuljis, J., Papazafeiropoulou, A., & Stergioulas, L. K. (2008). An

Evaluation Framework for Health Information Systems: Human, Organization and Technology-Fit Factors (HOT-fit). *International Journal of Medical Informatics*, *77*(6), 386–398. https://doi.org/10.1016/j.ijmedinf.2007.08.011

Yusof, M. M., Papazafeiropoulou, A., Paul, R. J., & Stergioulas, L. K. (2008). Investigating evaluation frameworks for health information systems. *International Journal of Medical Informatics*, *77*(6), 377–385. https://doi.org/10.1016/j.ijmedinf.2007.08.004

Yusof, M. M., Paul, R. J., & Stergioulas, L. K. (2006). Towards a Framework for Health Information Systems Evaluation. *Proceedings of the 39th Hawaii International Conference on System Sciences - 2006*, *00*(C), 1–10. https://doi.org/10.1109/HICSS.2006.491

Yusof, M. M., & Yusuff, A. Y. A. (2013). Evaluating E-government system effectiveness using an integrated socio-technical and fit approach. *Information Technology Journal*. https://doi.org/10.3923/itj.2013.894.906

Zander, F., & Kralisch, S. (2016). River Basin Information System: Open Environmental Data Management for Research and Decision Making. *ISPRS International Journal of Geo-Information*, *5*(7), 123. https://doi.org/10.3390/ijgi5070123

Zarli, A., Rezgui, Y., Belziti, D., & Duce, E. (2014). Water Analytics and Intelligent Sensing for Demand Optimised Management: The WISDOM Vision and Approach. In *16th Conference on Water Distribution System Analysis, WDSA 2014 An* (Vol. 89, pp. 1050–1057). Elsevier. https://doi.org/10.1016/j.proeng.2014.11.224

Zeb, J., Froese, T., & Vanier, D. (2012). Survey of Information Technology Use for Municipal Infrastructure Management. *Journal of Information Technology in Construction*, *17*(August), 179–193.

Zhang, K., Zargar, A., Achari, G., Islam, M. S., & Sadiq, R. (2014). Application of decision support systems in water management. *NRC Research Press*, *205*(May 2013), 189–205.

Zhang, P., Scialdone, M., & Ku, M.-C. (2011). IT Artifacts and the State of IS Research. In *International Conference on Information Systems* (p. 14). Shanghai.

APPENDIX A FACTOR LOADINGS

Table A-1: Factor loadings for the Technology dimension of the WMIS Success Framework

Indicator	Factor Loading		
	Iteration 1	*Iteration 2*	*Iteration 3*
	WMIS System Quality		
WSQ_1	0,761	0,761	0,758
WSQ_2	0,745	0,746	0,748
WSQ_3	0,740	0,757	0,758
WSQ_4	0,811	0,815	0,814
WSQ_5	0,768	0,777	0,778
WSQ_6	**0,690**		
	Service Quality		
SQ_1	0,884	0,884	0,885
SQ_2	0,835	0,835	0,835
SQ_3	0,801	0,801	0,801
SQ_4	0,782	0,782	0,783
SQ_5	0,830	0,830	0,830
	WMIS Information Quality		
WIQ_1	0,838	0,834	0,840
WIQ_2	0,824	0,825	0,824
WIQ_3	0,846	0,849	0,847
WIQ_4	0,844	0,843	0,842
WIQ_5	0,775	0,777	0,773

Table A-2: Factor loadings for the Human dimension of the WMIS Success Framework

Indicator	Factor Loading		
	Iteration 1	*Iteration 2*	*Iteration 3*
	User Satisfaction		
US_1	0,813	0,814	0,819
US_2	0,839	0,839	0,843
US_3	0,758	0,758	0,762
US_4	0,755	0,755	0,747
US_5	0,803	0,804	0,801
	System Use		
SU_1	0,769	0,768	0,761
SU_2	0,874	0,873	0,871
SU_3	0,805	0,809	0,813
SU_4	0,792	0,795	0,794

Table A-3: Factor Loadings for the Organisation dimension of the WMIS Success Framework

Indicator	Factor Loading		
	Iteration 1	*Iteration 2*	*Iteration 3*
	Leadership		
LP_1	0,886	0,886	0,886
LP_2	0,882	0,882	0,883
LP_3	0,842	0,842	0,842
LP_4	0,862	0,862	0,861
LP_5	0,852	0,852	0,852
	Structure		
SE_1	0,823	0,823	0,821
SE_2	0,818	0,819	0,816
SE_3	0,859	0,859	0,861
SE_4	0,834	0,833	0,837
	Environment		
ET_1	0,779	0,776	0,777
ET_2	0,866	0,865	0,862
ET_3	0,854	0,856	0,858
ET_4	0,838	0,840	0,840

Table A-4: Factor loadings for Net Benefits of the WMIS Success Framework

Indicator	Factor Loading		
	Iteration 1	*Iteration 2*	*Iteration 3*
	WMIS for Water Operations		
WWMO_1	0,867	0,869	0,881
WWMO_2	0,767	0,767	0,746
WWMO_3	0,414		
WWMO_4	0,703	0,706	
WWMO_5	0,737	0,738	0,797
	WMIS for Decision-Making		
WWDM_1	0,844	0,738	0,844
WWDM_2	0,841	0,842	0,841
WWDM_3	0,818	0,841	0,818
WWDM_4	0,765	0,819	0,764
WWDM_5	0,829	0,766	0,829

APPENDIX B INNER LOADINGS

Table 7-1: Inner Loadings of the WMIS Success Model

Hypothesis	Path	Path Estimate	t-value	p-value
H_{1a}	WSQ→SU	0,1767	2,9148	0,0039
H_{1b}	WSQ→US	-0,0158	-0,4090	0,6829
H_{1c}	WSQ→SE	0,0917	1,4987	0,1352
H_{2a}	WIQ→SU	0,2317	3,8269	0,0002
H_{2b}	WIQ→US	0,0449	1,1625	0,2461
H_{2c}	WIQ→SE	-0,0370	-0,6060	0,5450
H_{3a}	SQ→SU	-0,0029	-0,0299	0,9762
H_{3b}	SQ→US	0,7957	20,9540	0,0000
H_{3c}	SQ→SE	0,1223	1,2482	0,2131
H_{4a}	US→SU	0,0203	0,2098	0,8340
H_{4b}	US→SE	0,0074	0,0756	0,9398
H_{5a}	SU→WDM	0,2522	4,2602	0,0000
H_{5b}	SU→WMO	0,1087	2,5345	0,0118
H_{6a}	US→WDM	0,0756	1,2745	0,2036
H_{6b}	US→WMO	0,6914	16,1026	0,0000
H_{7a}	LP→SU	0,0991	1,6718	0,0958
H_{7b}	LP→US	0,0422	1,1154	0,2657
H_{7c}	LP→WDM	0,1606	2,6129	0,0095
H_{7d}	LP→WMO	0,0779	1,7507	0,0812
H_{7e}	LP→SE	0,2823	4,7244	0,0000
H_{8a}	SE→WDM	-0,0024	-0,0386	0,9692
H_{8b}	SE→WMO	-0,0492	-1,1062	0,2697
H_{9a}	ET→SE	-0,0702	-1,1947	0,2333
H_{9b}	ET→WDM	-0,0227	-0,3872	0,6990

H_{9c}	ET→WMO	0,1144	2,6882	0,0076

APPENDIX C CROSS LOADINGS

Table C-1: Cross Loadings of the Constructs

	WSQ	LP	SQ	WIQ	ET	US	SU	SE	WMO	WDM
WSQ_1	0,758	-0,012	0,143	0,244	-0,080	0,119	0,167	0,033	0,201	0,242
WSQ_2	0,748	-0,052	0,145	0,149	-0,014	0,103	0,156	0,008	0,134	0,157
WSQ_3	0,758	0,011	0,137	0,116	-0,146	0,126	0,109	0,073	0,089	0,123
WSQ_4	0,814	0,009	0,205	0,178	-0,007	0,150	0,213	0,093	0,169	0,184
WSQ_5	0,778	-0,038	0,162	0,113	0,027	0,110	0,194	0,162	0,111	0,113
LP_1	-0,015	0,886	0,045	0,152	-0,009	0,084	0,102	0,254	0,101	0,171
LP_2	-0,018	0,883	-0,013	0,178	0,025	0,019	0,182	0,254	0,159	0,192
LP_3	-0,032	0,842	0,008	0,147	-0,002	0,048	0,089	0,224	0,093	0,165
LP_4	0,015	0,861	0,011	0,151	-0,006	0,023	0,103	0,227	0,074	0,168
LP_5	-0,030	0,852	0,085	0,158	0,004	0,146	0,113	0,238	0,131	0,170
SQ_1	0,188	0,008	0,885	0,054	-0,008	0,666	0,086	0,170	0,479	0,058
SQ_2	0,170	0,000	0,835	0,077	-0,037	0,666	0,066	0,072	0,384	0,082
SQ_3	0,203	0,067	0,800	0,071	0,080	0,646	0,048	0,201	0,436	0,077
SQ_4	0,097	0,051	0,782	-0,004	-0,020	0,645	-0,024	0,101	0,378	0,003
SQ_5	0,195	0,012	0,830	0,084	0,109	0,677	0,100	0,071	0,654	0,082
WIQ_1	0,136	0,090	0,011	0,840	-0,016	0,036	0,259	0,020	0,099	0,829
WIQ_2	0,138	0,153	0,095	0,824	-0,013	0,103	0,227	0,020	0,172	0,829
WIQ_3	0,159	0,097	0,050	0,847	-0,025	0,070	0,223	0,046	0,101	0,838
WIQ_4	0,230	0,224	0,107	0,842	-0,046	0,146	0,247	0,066	0,171	0,844
WIQ_5	0,155	0,165	-0,001	0,773	0,054	0,051	0,231	0,016	0,108	0,772
ET_1	0,021	0,070	0,052	0,038	0,777	0,096	-0,037	-0,041	0,175	0,030
ET_2	-0,024	-0,038	-0,013	-0,036	0,862	0,031	-0,061	-0,065	0,114	-0,042
ET_3	-0,109	-0,006	0,059	-0,028	0,858	0,087	0,024	-0,035	0,181	-0,037
ET_4	-0,020	-0,004	0,008	-0,018	0,839	0,021	-0,048	-0,094	0,068	-0,024
US_1	0,117	0,064	0,603	0,052	0,159	0,819	0,070	0,082	0,797	0,046
US_2	0,089	0,060	0,608	0,079	0,043	0,843	0,084	0,155	0,611	0,079
US_3	0,089	0,066	0,528	0,063	0,008	0,762	-0,019	0,106	0,458	0,065
US_4	0,195	0,085	0,693	0,122	0,095	0,747	0,080	0,131	0,468	0,126
US_5	0,129	0,028	0,715	0,098	-0,045	0,801	0,077	0,047	0,445	0,099
SU_1	0,166	0,101	-0,009	0,306	-0,112	0,039	0,761	-0,065	0,063	0,297

SU_2	0,202	0,108	0,109	0,190	-0,041	0,116	0,871	-0,014	0,200	0,186
SU_3	0,189	0,128	0,029	0,260	0,046	0,028	0,813	0,011	0,120	0,258
SU_4	0,169	0,116	0,092	0,184	-0,001	0,064	0,794	0,047	0,161	0,177
SE_1	0,104	0,313	0,134	0,060	-0,026	0,124	0,022	0,821	0,066	0,069
SE_2	0,083	0,201	0,128	-0,004	-0,028	0,128	-0,026	0,816	0,055	0,006
SE_3	0,102	0,197	0,084	0,044	-0,110	0,050	-0,016	0,861	0,007	0,052
SE_4	0,069	0,188	0,153	0,035	-0,072	0,131	-0,013	0,837	0,049	0,037
WWMO_1	0,181	0,112	0,415	0,144	0,097	0,459	0,184	0,012	0,881	0,138
WWMO_2	0,154	0,165	0,295	0,229	0,131	0,335	0,185	0,025	0,746	0,226
WWMO_5	0,117	0,064	0,603	0,052	0,159	0,819	0,070	0,082	0,797	0,046
WWDM_1	0,230	0,224	0,107	0,842	-0,046	0,146	0,247	0,066	0,171	0,844
WWDM_2	0,162	0,097	0,060	0,848	-0,026	0,071	0,222	0,049	0,099	0,841
WWDM_3	0,143	0,195	0,094	0,796	-0,031	0,094	0,207	0,043	0,141	0,818
WWDM_4	0,154	0,174	-0,010	0,761	0,042	0,042	0,219	0,018	0,094	0,764
WWDM_5	0,136	0,090	0,011	0,840	-0,016	0,036	0,259	0,020	0,099	0,829

APPENDIX D PARAMETERS FOR MEASUREMENT MODEL

Table D-1: Cronbach's alpha, Dillion-Goldstein and Eigenvalues (1st) for all Iterations (Measurement Model)

Iteration 1				
Construct	MVs	Cronbach's α	DG Rho	Eigenvalue (1^{st})
WSQ	6,00000	0,84995	0,88901	3,43264
LP	5,00000	0,91602	0,93710	3,74401
SQ	5,00000	0,88428	0,91552	3,42338
WIQ	5,00000	0,88408	0,91526	3,41873
ET	4,00000	0,85525	0,90227	2,79200
US	5,00000	0,85415	0,89591	3,16675
SU	4,00000	0,82539	0,88460	2,63078
SE	4,00000	0,85520	0,90234	2,79319
WMO	5,00000	0,68265	0,79994	2,43523
WDM	5,00000	0,87986	0,91247	3,38051

Iteration 2				
WSQ	5,0000	0,8344	0,8832	3,0114
LP	5,0000	0,9160	0,9371	3,7440
SQ	5,0000	0,8843	0,9155	3,4234
WIQ	5,0000	0,8842	0,9154	3,4202
ET	4,0000	0,8552	0,9023	2,7920
US	5,0000	0,8546	0,8962	3,1704
SU	4,0000	0,8271	0,8856	2,6395
SE	4,0000	0,8552	0,9023	2,7932
WMO	4,0000	0,7771	0,8586	2,4274
WDM	5,0000	0,8799	0,9125	3,3805

Iteration 3				
WSQ	5,0000	0,8341	0,88298	3,0088
LP	5,0000	0,9160	0,93710	3,7440
SQ	5,0000	0,8843	0,91552	3,4234
WIQ	5,0000	0,8842	0,91535	3,4202
ET	4,0000	0,8552	0,90227	2,7920
US	5,0000	0,8546	0,89620	3,1704
SU	4,0000	0,8250	0,88432	2,6282
SE	4,0000	0,8552	0,90234	2,7932
WMO	3,0000	0,7417	0,85513	1,9977
WDM	5,0000	0,8799	0,91247	3,3805

APPENDIX E QUESTIONNAIRE

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Dear Participant,

This questionnaire will take about 10 minutes to complete and has a total of 10 sections. You are expected to provide answers to questions on your opinions of the Water Management Information System (WMIS) used in your organisation and questions on the structure and environment. Each section requires completion before proceeding to the next. For each of the questions, kindly choose the one you deem suitable in your opinion.

Thank you once again for your invaluable time. Please do not hesitate to send me an email at: kwesiamoako (at) gmail dot com if you require assistance to complete the questionnaire.

Sincerely,
Gordon Amoako
(UCT)

PARTICIPANT PROFILE

1. Please specify your gender

Male	Female	Other
☐	☐	☐

2. Please choose one that applies

	18 – 29
	30 – 39
	40 – 49
	50 – 59
	60 and above

3. Please select the WMIS that applies to your duties

	LIMS		PRP
	NIWIS		IMQS
	SEWSAN		SWIFT
	WADISO		Master Planner
Other			

4. Level of education

	High Sch./Matric		Postgrad
	Bachelor		Other

5. What is your current position?

6. Please specify your municipality

7. Please specify your department/section

8. How many years approximately have you been working in your current position?

9. Please specify the number of years you have been using the WMIS

WMIS SYSTEM QUALITY

This section requests your opinions of the WMIS system quality	strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
10. The WMIS is easy to use	☐	☐	☐	☐	☐
11. The WMIS is easy to learn	☐	☐	☐	☐	☐
12. The WMIS has useful functions and features for my tasks and duties	☐	☐	☐	☐	☐
13. The WMIS is secure	☐	☐	☐	☐	☐
14. The number of licensed machines available to use affects my use of the WMIS	☐	☐	☐	☐	☐
15. The WMIS is efficient (helps our work turnaround times)	☐	☐	☐	☐	☐

WMIS INFORMATION QUALITY

This section requests your opinions of WMIS with regards to the information quality	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
16. The information generated by the WMIS is accurate	☐	☐	☐	☐	☐
17. The information for the generation of WMIS report follow the right standards	☐	☐	☐	☐	☐
18. The information is reliable	☐	☐	☐	☐	☐
19. The information entered is traceable	☐	☐	☐	☐	☐
20. The WMIS information is accessible (easily and quickly retrievable when needed)	☐	☐	☐	☐	☐

SERVICE QUALITY

This section requests your opinions and expectations of quality of service or help provided within the organisation in helping you navigate system challenges	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
21. The system administrator/facilitator provides the needed assistance by the time promised or communicated	☐	☐	☐	☐	☐
22. The system administrator/facilitator is dependable in solving system problems and challenges	☐	☐	☐	☐	☐
23. The system administrator/facilitator is sincere in handling system challenges	☐	☐	☐	☐	☐
24. The system administrator/facilitator is always willing to help	☐	☐	☐	☐	☐
25. The availability of the system administrator/facilitator onsite is important in addressing system challenges I encounter	☐	☐	☐	☐	☐

SYSTEM USE

This section requests your opinions about the use of the system	Strongly disagree	Disagree	Neither agree/disagre e	Agree	Strongly Agree
26. I use the WMIS for my daily tasks and duties	☐	☐	☐	☐	☐
27. I have the required skills to use the WMIS	☐	☐	☐	☐	☐
28. I am motivated to continue using the WMIS for my tasks and duties	☐	☐	☐	☐	☐
29. I have the ability to use the required functions of the WMIS needed for my daily tasks and duties.	☐	☐	☐	☐	☐

USER SATISFACTION

This section requests your perception of how satisfied you are with the WMIS for your tasks and duties	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
30. The WMIS makes it easy to perform my tasks and duties	☐	☐	☐	☐	☐
31. The WMIS is useful in helping me undertake my tasks and duties	☐	☐	☐	☐	☐
32. I am satisfied with the functionalities available	☐	☐	☐	☐	☐
33. The WMIS provides the needed information in a timely manner	☐	☐	☐	☐	☐
34. I am satisfied with the WMIS overall	☐	☐	☐	☐	☐

WMIS FOR WATER MANAGEMENT DECISION-MAKING

This section requests your opinions of the use of the WMIS for water management decision-making	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
35. The WMIS supports decision making regarding my tasks and duties	☐	☐	☐	☐	☐
36. The WMIS information enhances the production of reports, documents and other knowledge products	☐	☐	☐	☐	☐
37. The WMIS information enhances policy, legislation and regulation (E.g. Blue/Green drop and others)	☐	☐	☐	☐	☐
38. The WMIS aids water management decision making outcomes (water quality, water demand, infrastructure planning and others)	☐	☐	☐	☐	☐
39. The quality of decision making is improved through WMIS use	☐	☐	☐	☐	☐

WMIS FOR WATER MANAGEMENT OPERATIONS

This section requests your opinions about the use of the WMIS for water management operations and administration	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
40. The WMIS supports operational duties of the water management process (E.g. enhancing the water quality monitoring process, water demand management, asset management and others)	☐	☐	☐	☐	☐
41. The WMIS aids operational duties that promote integrated water management	☐	☐	☐	☐	☐
42. WMIS enhances water management administrative duties required (E.g. order stocks and others)	☐	☐	☐	☐	☐
43. The WMIS enhances transparency and inclusivity in water management operations	☐	☐	☐	☐	☐
44. The WMIS is used for tasks that enhance infrastructure planning	☐	☐	☐	☐	☐

LEADERSHIP

This section requires your opinions on the role management/leadership plays regarding your duties and the use of WMIS for the duties	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
45. The leadership ensures that the needed support is provided when I encounter challenges in the use of WMIS for my duties	☐	☐	☐	☐	☐
46. When I produce work that affects the decision-making process, my superior and management recognise and commend me	☐	☐	☐	☐	☐
47. Management follows-up regularly on the work and tasks I am assigned to ensure there are no errors or problems	☐	☐	☐	☐	☐
48. Leaders have a good understanding of how the WMIS functions	☐	☐	☐	☐	☐
49. Leaders encourage and support working together, including asking colleagues for help when the need arises	☐	☐	☐	☐	☐

STRUCTURE

This section requests your opinions about the organisation with regards to how the structure of the organisation supports use of the WMIS	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
50. Communication between the different departments/sections improve my use of the WMIS	☐	☐	☐	☐	☐
51. Integration between the different departments/sections improve my use of the WMIS	☐	☐	☐	☐	☐
52. The organisation's goals, vision and strategy are clearly defined	☐	☐	☐	☐	☐
53. The organisation provides the infrastructure needed for the WMIS use	☐	☐	☐	☐	☐

ENVIRONMENT

This section requests your opinions about the organisation with regards to how the environment of the organisation supports use of the WMIS	Strongly disagree	Disagree	Neither agree/disagree	Agree	strongly Agree
54. Financing influences the use of the WMIS (E.g. not being able to purchase more licenses for the systems)	☐	☐	☐	☐	☐
55. The outcome of the desired service quality for our clients affects how I perform my tasks	☐	☐	☐	☐	☐
56. I easily ask my colleagues for help, share skills and knowledge about the WMIS when the need arises	☐	☐	☐	☐	☐
57. There is no competition among my colleagues regarding our tasks and duties	☐	☐	☐	☐	☐

APPENDIX F UCT ETHICS APPLICATION AND APPROVAL

UNIVERSITY OF CAPE TOWN
FACULTY OF COMMERCE
Igniting Knowledge and Opportunity

Commerce Faculty Ethics in Research Application Form

Any person planning to undertake research in the Faculty of Commerce at the University of Cape Town is required to complete this form **before collecting or analysing data**. If any of the questions below have been answered YES, and the applicant is NOT an Honours student, the form it should be submitted to the supervisor (where applicable) and from there for approval by the Faculty EIR committee: Ms Samantha Alexander (samantha.alexander@uct.ac.za).

It is assumed that the researcher has read the UCT Code for Research involving Human Subjects (Available at http://web.uct.ac.za/depts/educate/download/uctcodeforresearchinvolvinghumansubjects.pdf) in order to be able to answer the questions in this form.

Students must include a copy of the completed form with the dissertation/thesis when it is submitted for examination.

1. PROJECT DETAILS			
Project title: Development of an evaluation framework for ICTs in the South African Water			
Principal Researcher/s: Gordon Amoako	**Email address(es):**	kwesiamoako@gmail.com	
Research Supervisor: A/Prof. Ulrike Rivett	**Email address(es):**	ulrike.rivett@uct.ac.za	
Co-researcher(s):	**Email address(es):**		
Department: Information Systems			
Brief description of the project: Over the last decade, ICTs are being used to tackle planning,monitoring and management challenges that the water sector faces.A variety of ICTs have emerged for improvement of revenue collection, water quality reporting, Smart Water Systems (SWS), customer management, citizen engagement systems, measuring and reporting on technical performance, monitoring and fault reporting etc.However, literature on the performance of ICTs in the water sector over the past decade in South Africa and other African countries has not been substantial. Whilst several authors have acknowledged the importance and role of ICTs in the water sector, there is a lack of research on their assessment or evaluation. This research develops a framework for the evaluation of ICTs in the South African water sector based on identified indicators from municipal water structures. The indicators to be identified cover technical and social dimensions.			
Data collection: (please select) ☒ Interviews ☒ Questionnaire ☐ Experiment ☒ Secondary data ☐ Observation ☐ Other (please specify): ______			
Have you attached a research proposal OR a literature review with research methodology? (please select) ☒ Yes ☐ No			

I certify that I have read the the Commerce Faculty Ethics in Research policy ☒   **(http://www.commerce.uct.ac.za/Pages/ComFac-Downloads)**

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:	GORDON AMOAKO (AMKGOR001)	12 OCTOBER, 2015

This application is approved by:

Supervisor	A/PROF. ULRIKE RIVETT	12 OCTOBER, 2015
HOD (or delegated nominee – for all Honours Projects):		
Chair: Faculty EIR Committee (only for postgraduate research at Master and PhD level)		3 Dec 2015

Figure F-1: Ethics Approval from the Faculty of Commerce Ethics

APPENDIX G CITY OF CAPE TOWN ETHICS

Approved: Research Interview and Information Request

Nina Viljoen <Nina.Viljoen@capetown.gov.za> 20 May 2016 at 09:53
To: "Gordon Nana Kwesi Amoako (kwesiamoako@gmail.com)" <kwesiamoako@gmail.com>
Cc: Jaco de Bruyn <jaco.debruyn@capetown.gov.za>, Mario Carelse <Mario.Carelse@capetown.gov.za>

Dear Gordon

Approval: Research Interview and Information Request for Project Titled: "Evaluation of Water Management Information Systems (WMIS) in the South African water sector".

The City of Cape Town is pleased to inform you that your research interview and information request for the above mentioned research project has been granted. Please find attached document as your proof of approval. For any interview or information enquiries you can contact our Integrated Planning, Strategy & Information Management Branch, Tel: 021 444 0736: Mr Jaco de Bruyn.

We wish you all the best with your research study.

Kind Regards

Nina Viljoen MSc, *Cum Laude (Cert.Sci.Nat)*

Research and Development Officer

Quality Management Systems

Water Demand Management & Planning

Water and Sanitation
2nd Floor, Cnr Victoria and Main Str

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Figure G-1: Approval Email Response from City of Cape Town

W05/c21/600

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STAD KAAPSTAD

WATER AND SANITATION

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RMEMO:13

Research Study, Data or Interview Permission Request

Date:	15 April 2016
For Approval By:	Dr Gisela Kaiser, Executive Director: Utility Services
Subject:	Research Study Permission – Mr. Gordon Amoako, PhD Student, UCT
Purpose:	Request for focus group/interviews and 3-iteration survey: Evaluation of Water Management Information Systems (WMIS) in the South African water sector.
Research Request Received on:	12 April 2016

Seeking permission for research study as follows:

(a) Request for focus group/interviews and 3-iteration survey with stakeholders and users regarding Water Management Information Systems (WMIS) implementation and use within water management structures.

Background

The aim of this study is to understand the impact of information systems on overall water management through a human, organization and technology-fit perspective. Dimensions such as system quality, information quality, system use, user satisfaction, structure, environment, service quality and net benefit will be explored. To understand these dimensions, the municipality's information flow and structure, history of the systems, business processes, decision on the systems implemented or

to be implemented and the information systems design and development process must be understood. A core focus is to undertake interviews/focus groups discussion and surveys with experts, stakeholders, users of these systems, developers and decision-makers involved with these tasks.

Questions as requested as part of the process for approval of research requests:

Question 1

Please provide a formal research proposal highlighting the research topic, hypothesis (if applicable), research methodology and intended sample group. The impact on the time participants would need to complete the research is also needed and must be clearly stated. Also, how would the researcher envisage accessing the participants? What would you require from the City for the research project- i.e. interviews, data etc.?

Answer: RESEARCH TOPIC: Evaluation of Water Management Information Systems (WMIS) in the South African water sector.

Over the last decade, the Water and Sanitation sector in South Africa and other African countries has experienced an increasing use of Water Management Information System (WMIS)/Information and Communication Technology (ICT). WMISs are being used to tackle planning (land and spatial management, assets and others), monitoring and management challenges that the water sector has faced over the years. A core thrust of the South African Department of Water and Sanitation's (DWS) proposed National Water Resource Strategy 2 (NWRS 2) is to invest and expand WMIS use in South African the water sector (DWA 2012:35). Thus, assessments of implemented WMISS/ICTs will become paramount to understanding performance, enablers, barriers and other challenges if there is an intention of implementation and successful expansion in the sector. However, literature on the performance of WMIS in the water sector over the past decade in South Africa and other African countries has not been substantial. In order to improve the position of government and stakeholders to make informed decisions regarding ICT investment and expansion, evaluation of ICTs in the water sector is needed at the municipal, provincial and national levels.

The aim is to understand the impact of information systems on overall water management through a human, organization and technology-fit perspective. Dimensions such as system quality, information quality, system use, user satisfaction, structure, environment, service quality and net benefit will be explored. To understand these dimensions, the municipality's information flow and structure, history of the systems, business processes, decision on the systems implemented or to be implemented and the information systems design and development process must be understood. A core focus is to undertake interviews/focus groups discussion and surveys with experts, stakeholders, users of these systems, developers and decision-makers involved with these task.

Question 2

What are the set deliverables of the research project?

Answer: Thesis that explores the of human, organisation and technology-fit dimensions of Water Management Information Systems (WMIS) within the structures of the South African water sector.

Question 3

A letter from the relevant tertiary institution confirming the researcher is a registered student and confirming the qualification the researcher is pursuing and that the researcher will be required to conduct research in order to obtain the qualification.

Answer: Letter attached.

Question 4

A mini project plan explaining the essence and duration of the research.

Answer: ACTIVITY 1: Stakeholder interview/focus group discussion. PURPOSE: Understanding: work processes, information flow, information systems planning and implementation; strategies for information systems implementation and use; aspects to do with funding, systems and information quality; implementation challenges and perceived benefits. DURATION: 1-2 Months

ACTIVITY 2: Delphi Survey. PURPOSE: Exploring the human, organisation and technology-fit dimensions identified from the earlier interview/focus group discussion. DURATION: 2 – 3 Months in relation to the municipal water management (3 iterations).

Question 5

Which institutions and or organisations are involved in conducting, directing and/or commissioning the research study?

Answer: This PhD research is being undertaken at the University of Cape Town.

Question 6

Is the City the only government sphere or municipality stakeholder in this project? If so why, and if not who are the other stakeholders?

Answer: During the research, interview developers of the information systems identified within the working structures of the municipality. This is based on the framework being used for the study. Other stakeholders from institutions like the Department of Water and Sanitation (DWS), Water Research Commission (WRC) and 2 other municipalities will be interviewed.

Question 7

Are there any other non-governmental/private stakeholders involved in this research?

Answer: No non-governmental/private stakeholders are involved in this research.

Question 8

What benefit does this research hold for the City?

Answer: Some of the benefits the study holds for the City include: □ Provision of knowledge on various dimensions - human, organisation and technology-fit affecting the implementation of WMISs with the municipal water structures; and □ Aiding stakeholders and decision-makers with regards to considerations bothering on design, development and investment into appropriate WMISs that affect the various processes.

Question 9

Confirmation of the confidentiality of the research and the City's right to request that the name and brand of the City will not be used in the research publication unless this is with the City's consent.

Answer: I hereby state that results from this research will not be shared with any third party or for any research publication without the consent of the City or proper referencing.

Annexures:

Annexure A:	Signed Research Data Request/Confidentiality Agreement
Annexure B:	Letter from Supervisor

Recommendation/s

The City of Cape Town, Water and Sanitation Department supports this research data request. Information required does not contravene the Protection of Personal Information Act. The research will be of value to the City of Cape Town and is recommended by the Department.

Approval Subject to Conditions: Yes ☐ /No ☐

If yes, please specify: ______________________________

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MARIO CARELSE Recommended ☑/Not Recommended ☐ 22/4/2016 Date
IMS SPECIALIST: WATER AND SANITATION

COMMENTS: ______________________________

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JACO DE BRUYN Recommended ☑/Not Recommended ☐ 25 4 - 2016 Date
HEAD: INTEGRATED PLANNING,
STRATEGY AND INFORMATION MANAGEMENT
(DATA CUSTODIAN)

COMMENTS: ______________________________

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DR GISELA KAISER Approved ☒/Not Approved ☐ 3/5/2016 Date
EXECUTIVE DIRECTOR: UTILITY SERVICES

COMMENTS: ______________________________

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RESEARCH STUDY OR DATA/INFORMATION PERMISSION REQUEST & CONFIDENTIALITY AGREEMENT			CITY OF CAPE TOWN ISIXEKO SASEKAPA STAD KAAPSTAD	
W&S/R002	05/08/2015	WATER AND SANITATION DEPARTMENT	Version: 1	Page 1 of 7
COMPILED: N. VILJOEN			APPROVED: C MUBADIRO	

WATER AND SANITATION – RESEARCH

EXTERNAL RESEARCH ASSISTANCE OR INFORMATION/DATA REQUEST & CONFIDENTIALITY AGREEMENT

* **All applicants must please answer each category in detail.**
* **Applications do not necessarily guarantee commitment by the Research Section to consider or provide the requested research assistance or information/data.**
* **The research section reserves the right to decline such application based on specialised research requirements and availability of resources/data.**
* **This document should be signed and attached to the research approval report for final approval signatures.**
* **All research requests to be approved by the Office of the Executive Director: Utility Services**

Section 1: Requesting Institution/Organisation Details	
Institution/Organisation Name:	University of Cape Town
Department/Section Name:	Department of Information Systems
Institution/Organisation Address:	Leslie Social Building, Level 3. Upper Campus. Rondebosch, 7701
Section 2: Requesters Details	
Requesters Name:	Gordon Amoako
Student Number or Designation:	AMKGOR001
Contact Details of Requester:	Tel:
	Cell: 0710000762
	Email:
	Fax:
Person Accepting Responsibility for Provided Information	Gordon Amoako
Section 3: Requested Research Assistance or Information	

Figure G-2: Ethics Application - City of Cape Town, South Africa

APPENDIX H WMIS IMPLEMENTATION IN THE COCT DEPARTMENT OF WATER AND SANITATION

The WSAs responsibilities of protecting and managing water resources, infrastructure operations and maintenance, monitoring and management of drinking water quality and other essential duties are enhanced by these systems (DWS, 2010, 2015; Republic of South Africa, 1997). Two WMISs which are critical to the department's core operations and decision-making, and informed the model, are presented below.

LIMS Water Quality System

LIMS is a collection of both hardware and software used for collecting, processing, storing and retrieval of water quality data. The City of Cape Town Metropolitan Municipality relies on the system to test and track the quality of water at regular intervals before it reaches the consumers. Results from the water samples, the most crucial aspect of the process, are sent to relevant stakeholders along the value chain, notably the CoCT's health directorate for the appropriate actions to be taken. A LIMS administrator is responsible for ensuring that the system functions as expected without any hindrance. It includes managing the users of the system, and other user needs, including the addition of functionalities where necessary and in line with the various standards, reports and other requirements. The system also a has reporting functionality which is used on a daily basis for decision-making. To safeguard the quality of health of the citizenry the city has to adhere to strict water quality guidelines based on South Africa's Blue Drop System (BDS). The BDS is a system developed by the South African Department of Water and Sanitation (DWS) to ensure compliance and operational aspects of water treatment system. It is the de facto system used for South Africa's water quality regulatory performance (DWS, 2014). Samples are taken at specified consumer points and brought for testing and tracking regularly.

LIMS feeds into the Blue Drop System via the electronic Water Quality Management Systems (eWQMS) either in an automated manner or for places where internet connectivity is a challenge it is mandatory for the respective water management institution to upload it manually.

eWQMS

The electronic Water Quality Management System (eWQMS) is a web-accessible open source water quality management tool. Water quality data from all WSAs in South Africa are uploaded monthly via the internet, a spreadsheet or specialised scripts. The system has inbuilt functionality that provides automated regulatory compliance reporting to all WSAs and relevant stakeholders. The system follows standards set by the primary institutions responsible for water management quality and operational compliance, that is, the WSAs, IMESA, DWS and WRC. It provides easy access to the loading of water quality data and interpretation based on standards like SANS 241.

Further, it has visual dashboards for all aspects of water quality monitoring and operations. The system also has a map-based functionality which is important for mapping out water quality data. Aside from these functionalities, there are inbuilt analytical tools built into the system for quick and detailed analysis of regular operational functions and other legislative compliance. It also has automated functionality which sends regular monthly reports with an overview of the drinking water status to relevant stakeholders for action.

Regarding the infrastructure, eWQMS provides tools for capturing the WSA infrastructure details related to aspects like the abstraction points, sampling or reticulation points, laboratories utilised, treatment systems, storage facilities and other essential aspects. There are inbuilt assessment tools used to perform risk profiles. WSAs can undertake self-assessment using this tool. An example has been the use of eWQMS for a strategic level water quality management sustainability or gap analysis, and a drinking water and treatment plant distribution network assessment and risk profile by the WRC (DWS, 2010).