SUSTAINABLE CITIES WATER INVESTMENT AND MANAGEMENT FOR IMPROVED WATER SERVICE DELIVERY: CASE STUDY OF SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

by

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THESIS

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DECLARATION

I declare that "**SUSTAINABLE CITIES WATER INVESTMENT AND MANAGEMENT FOR IMPROVED WATER SERVICE DELIVERY: CASE STUDY OF SOUTH AFRICAN METROPOLITAN MUNICIPALITIES"** thesis hereby submitted to the University of Limpopo, for the degree of Doctor of Commerce (Accounting) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

Mukwarami, S (Dr) 28 October 2021

DEDICATION

I dedicate this study to the creator, the one above us, who, through his holiness, gave me holy power to complete my thesis in time. I also dedicate this study to everyone involved in fighting COVID 19. Additionally, special dedication goes to my family members for their unwavering support, particularly my late father, Joseph Mukwarami, for his encouragement.

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ABSTRACT

Despite South Africa's progress towards increasing investments in water management (IWM), water services delivery challenges (WSDCs) are prevalent. However, this further proves that focusing on only increasing (IWM) without addressing sustainability practices is not the only lasting solution. Therefore, the study examined the relationship between Sustainable Water Infrastructure (SWI) factors and IWM in South African metropolitan municipalities (SAMMs) to explore an alternative way of dealing with WSDCs. The study considered 278 municipalities in South Africa as the population. Furthermore, the study purposively selected eight (8) SAMMs, and employed quantitative content analysis to collect secondary data (2009 to 2019) from the various internet-based data sources. The data analysis procedure involved multivariate regression analysis through which Ordinary Least Squares and Feasible Generalised Least Squares produced results for the study. The study results suggest that only environmental management practices have had a positive but insignificant effect on IWM, whereas social, governance and economic factors have adversely and insignificantly influenced IWM. Overall, the relationship between SWI factors and IWM in SAMMs has turned out to be neutral. The results further expose the metropolitan councils' lack of proactive strategies to deal with the SWI factors that impede progressive efforts towards addressing an underinvestment gap and the worsening WSDCs. Since the study pioneered in the water management narrative, it has initiated new approaches to addressing WSDCs in the South African context. The study results present important implications for water service authorities and policymakers in South Africa as the narrative concerning the development of sustainable cities continues to gain momentum in urban development discourses. The study further recommends that SAMMs adhere to guidelines proposed in the framework to ensure that created investment opportunities due to good SEGE practices can enhance IWM. Lastly, further studies in this field of study are fundamental in exploring various approaches to addressing WSDCs.

Key words: water investment, practices, sustainable water infrastructure factors, South African metropolitan municipalities, water services delivery challenges

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LIST OF ACRONYMS AND ABBREVIATIONS

CENWI	Capital Expenditure New Water Asset
CGPs	Corporate Governance Practises
CRSA	Constitution of Republic of South Africa
DWS	Department of Water and Sanitation
EHOCR	Expenditure on Housing Opportunities Created
EMPs	Environmental management Practises
EMWAS	Expenditure on the Maintenance of Water Assets
EOEPM	Expenditure on Environmental Protection Management
EOWWM	Expenditure on Wastewater Management
FEM	Fixed Effect Models
FGLS	Feasible Generalised Least squares
FMOLS	Feasible Modified Ordinary Least Squares
FMPs	Financial Management Practices
FP	Financial Performance
GLAAS	Global Analysis Assessment
IWM	Investment in Water Management
NOSMA	Net Operating Surplus Margin
NWIF	National Water Investment Framework
NREWA	Non-Revenue Water
NWRS	National Water resources Strategy
OLS	Ordinary Least Squares
PBWAR	Pipe-Borne Water Access Rate
POPSZ	Population Size
PSD	Poor Service delivery
REM	Random Effect Model
SACN	South Africa Cities Network
SAMMs	South African Metropolitan Municipalities
SDGs	Sustainable Development Goals
SEGE	Social, Environmental, Governance, Economic
SIPs	Sustainable Investment Projects
SWI	Sustainable Water Infrastructure
SWIF	Sustainable Water Infrastructure Footprint

TOIWM	Total Investment in Water Management
TVASS	Total Value of Assets
VIF	Variance Inflation Factor
WASH	Water, Sanitation and Hygiene
WOGOS	Women in Management and Female Councillors
WPSTE	Water Professionals and Technically Skilled Employees
WSI	Water Sector Investment
WSAs	Water Services Authorities
WSDCs	Water Services Delivery Challenges
WSDS	Water Services Delivery System
WSPs	Water Service Providers
WSIC	Water Supply infrastructure Capacity

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

"Among the many things that I learned as president was the centrality of water in the social, political and economic affairs of the country, the continent and the world."

Nelson Mandela, the former president of South Africa, made the above statement during the 2002 World Summit on Sustainable Development in Johannesburg. Indeed, water has become the oil of the 21st century and is a common denominator in achieving sustainable development goals (SDGs) as it flows through the pillars of all sustainability dimensions (United Nations International Children's Emergency Fund (UNICEF) (2015). Water is fundamentally vital for maintaining energy and food security and promoting socio-economic growth and sustainability of the ecological environment in the world (Samuel, Mbabazize & Shukla, 2016). Despite efforts towards recognising water as a critical resource in achieving sustainable development goals (SDGs), UNICEF's (2015) report on water and sanitation accessibility suggest that close to 748million people around the globe were living in water stress conditions. Similarly, Guppy and Anderson's (2017) report on the water crisis suggests that around a 1.8billion people access water from sources contaminated with human waste. On the same note, a projection by the same authors suggests that the gap between water demand and water availability will increase to 40% by 2030. As such, infringements of citizens' rights to access safe and clean drinking water perpetually presents a fundamental global challenge to the water services authorities (WSAs) (World Water Council (WWC), 2014). The global responses to water supply insecurity challenges are characterised by increased spending on an expanding sustainable water infrastructure footprint (SWIF) to meet the increasing demand for water services, particularly in cities. Notwithstanding the significance of increased investment in water management (IWM), WSDCs persist unabated. Therefore, considering the dynamic and uncertain environment in which water service providers (WSPs) are operating, a collaboration of multifaceted mechanisms for confronting SWI management hurdles are indispensable to seeking permanent solutions to the existing WSDCs.

In considering water insecurity issues, Africa's 2063 agenda set inclusive growth and sustainable development (goal 7) to eradicate poverty by ensuring water and sanitation provision remains a significant priority in building sustainable urban areas (The African Union

Commission, 2015). Also, around the globe, United Nations' sustainable development roadmap recognises water insecurity challenges as an obstacle to achieving sustainable cities status as narratives relating to the management of water infrastructure remain unresolved (Infrastructure Dialogue, 2015). The rise in cities' expansion around the world has resulted in hotspots for severe WSDCs because of numerous factors such as climate change, population growth, rapid urbanisation, poor governance, outdated infrastructure and funding challenges (Butler, Ward, Sweetapple, Astaraie-Imani, Diao, Farmani & Fu, 2016; Schleifer, 2017). However, these factors have contributed a great deal towards ineffectiveness and inefficiencies in water infrastructure functioning, resulting in a series of endless WSDCs. Besides, the Asia Development Bank (ADB) (2017) posits that the existing SWI underinvestment gap is one of the deterrent factors that has constrained WSAs from adopting modern SWI technology to improve the efficiency and effectiveness of water services delivery systems (WSDSs). Given the persisting WSDCs globally, it has emerged that without putting in place a proper framework for developing and maintaining the existing SWI in cities, the notion of building sustainable cities remains a pipe dream. Therefore, business-as-unusual approaches in the management of SWI may assist in addressing WSDCs in cities.

The rhetoric on increasing SWI investments has gained momentum amid pressure emanating from the global water stakeholders to modernise the existing integrated WSDSs to circumvent challenges emerging from a dynamic environment. A substantial increase in IWM was attributed to an improved global safe drinking water access rate to 91% in 2010 (World Health Organisation (WHO) (2014). However, the existing SWI underinvestment gap remains a bone of contention in achieving SDG 11, which calls for the development of sustainable and liveable cities. The lack of water infrastructure investment has resulted in challenges including an increase in unaccounted water, water supply disruptions and failure to replace obsolete infrastructure with technologically advanced ones (Kane, 2016; Schleifer, 2017). The challenge of the SWI underinvestment gap is quite phenomenal even in developed countries like the United States of America and the United Kingdom: losing over 3 billion gallons of water daily because of water leaks caused by obsolete infrastructure. In attempting to confront water sector investment (WSI) challenges created by SEGE factors, most developed economies, particularly the Organisation for Economic Co-operation and Development (OECD) member states decided to spend 2.5% of their GDP on infrastructure development (OECD, 2015). Similarly, countries like Israel and Singapore have established sound and coherent frameworks for addressing water scarcity problems by investing heavily in cutting edge SWI technology (ADB, 2017). However, despite the substantive increase in the IWM, water deficit remains, implying that attention aimed at addressing WSDCs should encompass increasing investments as the global climate change effects continue to create uncertainties (Guppy & Anderson, 2017).

Particularly in developing regions such as the Caucasus and Central Asia, Northern Africa, Oceania, and Sub-Saharan Africa, water scarce conditions still exist as evidenced by the failure to meet the Millennium Development Goals target for safe drinking water (88%) (UNICEF, 2015 & WHO, 2015). In the context of Africa, Sub-Saharan Africa is one of the hotspots for WSDCs, and in addressing the problem, the African Capacity Building Foundation (ACBF) (2016) suggests that US$11billion is required against the backdrop of a substantial underfunding gap. Africa's water infrastructure systems are characterised by ageing water infrastructure, which is digitally incompatible with sustainable development needs (ACBF, 2016). However, due to obsolete water infrastructure in Africa, the challenge of loss of water revenue adversely affects the continent by over US$1billion annually (PricewaterhouseCoopers (PWC), 2014). Additionally, the African Development Bank (AfDB) (2019) suggests that Africa is losing 5% of the gross domestic product (GDP) due to persistent WSDCs challenges. Therefore, a need to focus on achieving inclusive growth and sustainable development as envisaged in African Agenda 2063 remains a hot topic. Regarding IWM, WSAs in the major cities require to start thinking outside the box by ensuring that the focus is not on increasing IWM but going beyond what drives IWM to achieve SDGs and African Agenda 2063.

In the South African context, it is vital to acknowledge the progress made concerning improvement in SWIF across the country. According to South Africa's (Stats SA) (2019) household general survey, households' access to safe drinking water increased to 88.2.0% in 2019. The government continues to make endless efforts in improving the SWIF across the country, but the lack of funding remains a challenge in achieving SDG 11. According to UN-Water and WHO's (2017) global analysis and assessment (GLAAS) report on the 2016 WSI framework, a total of US$6.4 billion is required to meet the SWI investment needs towards the provision of water and sanitation in the coming ten years. Similarly, a total of US$6.2 billion is required for the maintenance of existing SWI and the acquisition of new water assets. Given the SWI underfunding gap, debate on factors that determine the SWI investment needs is imperative in seeking answers to why WSDCs persist despite a substantial increase in IWM. Therefore, a new paradigm shift in the management of WSI is imperative in addressing WSDCs.

Notably, the challenges that inhibit the proper functionality of SWI and management of investment in the water sector mostly relate to institutisaonal capacity, technological innovation, engineered infrastructure, finance, policy and regulation, ecological infrastructure and culture and social values (Worldwide Fund for Nature-South Africa (WWF-SA), 2016). Various studies have identified challenges that have persistently derailed government efforts to create a stable water investment environment crucial to addressing the SWI underinvestment gap and WSDCs. These challenges are ageing infrastructure (Ruiters, 2013), vandalism and theft of infrastructure components (Infrastructure Dialogue, 2015), and climate change-induced risks that affect the functionality of SWI (Schweikert, Chinowsky, Espinet & Tarbert, 2014; Leigh, 2016). Additionally, weak corporate governance practices (CGPs) have promoted corruption and mismanagement of funds (Maclean, 2015; Jacobs, 2019). Further, WWF-SA (2016) notes that 70% of existing SWI is collapsing because of asset neglect and low maintenance, while 80% of the existing water infrastructure is not compatible and digitally unfit to be integrated with modern water infrastructure components. Likewise, the failure to effectively govern water infrastructures has continued to increase the water loss, which was estimated to be 39.5% in 2018 (Department of Water and Sanitation (DWS), 2018). Therefore, a water infrastructure dialogue remains relevant in seeking solutions to SWI challenges which have strong links with IWM.

In response to infrastructure deficit programmes, various post-independence infrastructure development programmes were initiated, including the Reconstruction and Development Programme (RDP), Growth Employment and Redistribution (GEAR) and Accelerated Shared Growth for South Africa (ASIGSA) (Hollingworth, Koch, Chimuti & Malzbender, 2011). The country also initiated the United Nations SDGs-aligned National Development Plan, which focuses on extensive infrastructure development by 2030 (National Planning Commission, 2011). Furthermore, a 2013 revised version of the National water resources Strategy (NWRS) ensures the efficiency and effectiveness of water resources management considering equitable and sustainable growth and development needs (DWA, 2013). The National Water Investment

Framework (NWIF) since 2017 is to create a stable investment environment for the water sector by ensuring that costs relating to the sustainable water supply align with the revenue-generating capacity of the economy and water resources (DWS, 2018). In ensuring these infrastructure development programmes' success, South Africa established a strong and sound legal framework. This framework includes the Constitution of South Africa Act 108 of 1996; the National Water Act (Act 36 of 1998); the Water Services Act (Act 108 of 1997); the Municipal System Act (Act 32 of 2002); and the Municipal Finance Management Act (Act 56 of 2003) and the White Paper on National Water Policy, which guides all water use activities. Therefore, despite immense efforts, the persistence of WSDCs across the municipalities in the country implies that a new approach in ensuring that the SWI underinvestment gap is imperative in achieving optimal water security.

Regarding the prevailing WSDCs, it is fundamentally vital to acknowledge that SWI provides a link between water sources and water consumers, but the infrastructure deficit caused by underinvestment is one of the main problems. However, it has become imperative to acknowledge that SWI components are vulnerable to social, economic, governance and environmental (SEGE) factors that tend to influence their functionality and affect IWM. Various corporate governance factors have had positive, neutral and negative, direct or indirect impacts on IWM as indicated in the literature (Maclean, 2015; Achim, Borlea & Mare, 2016; Ionascu, Ionascu, Sacarin & Minu, 2018). Besides, environmental management factors proved to have varied impacts on IWM. However, various studies alluded to the fact that poor EMPs have negatively impacted IWM through the destruction of SWI (Juana, Makepe & Mangadi, 2012; Schweikert *et al.*, 2014; Koop & Van Leeuwen, 2017). Conversely, other studies found EMPs positive association with increased firm performance (Horta, Camanho, Dias & Niza, 2016; Ali, Zailani, Iranmanesh & Foroughi, 2019). Concerning social factors' effects on IWM, a few studies produced positive outcomes (Glossop, 2008; Gomez, Perdiguero & Sanz, 2019); while others found negative results (Asoka, Thuo & Bunyasi, 2013; Mukherjee & Chakraborty, 2016). Finally, extant literature also proves that economic factors have had a positive influence on IWM (Başci & Başci, 2016), yet other scholars found a negative association (Maclean, 2015; Güngör-Demirci, Lee, Keck, Guzzetta & Yang, 2018). Given the inconclusive direct and indirect relationship between SWI factors and IWM, it is apparent that further interrogations into the matter are crucial in seeking solutions to long-standing WSDCs.

Additionally, various studies conducted in South Africa confirm that existing WSDCs are linked to many factors. Maake and Holtzhause (2015) pointed out the factors affecting the provision of sustainable water service in the Mopani District Municipality include ageing infrastructure, lack of technical skills, provision of non-revenue water and inadequate water resources. Ruiters (2013) critically analysed existing funding models for financing water infrastructure intended to address the water industry's investment gap and found that improvements to the current model of financing SWI are needed. However, of great concern is the unprecedented growth of South African cities (South African Cities Network (SACN), 2016) against the backdrop of already prevailing WSDCs linked to underinvestment in SWI, which, in turn, is a function of SEGE factors. As such, the existence of the endless WSDCs in South Africa's main cities further exposes local governments' ineffective approaches of governing WSDSs and the impacts of SWI factors (SEGE factors) on IWM may remain unexplored, undetermined, and unquantified. Therefore, further interrogation into this matter is pertinent to realising the dream of building sustainable cities equipped with digitally advanced SWI technology to assist WSAs in creating investment potentials out of good SEGE factors that would help manage uncertainties within the water sector environment.

From the background given, it has become clear that massive investments in SWI are required. Despite the researcher agreeing with this notion, a sustainability approach involving a framework that considers underlying SEGE factors is pertinent to managing water investments by lessening the government's funding burden. As such, this study focuses on investigating the relationship between SWI factors and IWM in South Africa's metropolitan municipalities (SAMMs) to influence water stakeholders to immediately act to arrest the deepening crisis of the SWI underinvestment gap.

1.2 PROBLEM STATEMENT

Water is critical for human health and growing the economy and maintaining the ecological environment and habitat (DWS, 2017c). Despite water being an essential socio-economic component of sustainable development, infrastructure for its procurement, transportation, and distribution remains a significant challenge (Hollingworth *et al.,* 2011). According to Leigh (2016), high water demand in cities is seen against the backdrop of SWI deficiencies, thus, creating inconsistencies in supplying water services. Amid a myriad of water infrastructure challenges, issues such as the infrastructure's age, limited infrastructure capacity to meet high water demand, weak governance of infrastructure, and climate change-induced infrastructure effects (Infrastrcture Dialogue, 2015) require attention to improve water security. As such, without a substantial investment in the maintenance and acquisition of SWI (Rodriguez, van den Berg & McMahon, 2012), the availability of sustainable water provisioning in cities remains a far-off goal. However, literature pointed out that most countries have continued to increase IWM, but WSDCs remain a permanent feature in cities. Given the endless WSDCs, it is yet to be known if evaluating the impacts of SEGE factors on IWM might assist in addressing WSDCs.

Despite South Africa being a water-scarce country, there has been remarkable progress in water provision in cities (Hollingworth *et al.*, 2011). However, the prevailing water quantity and quality inconsistencies are mainly due to SWI challenges (Infrastructure Dialogue, 2015), and are a cause of great concern in the repertoires of sustainable development discourses. In this regard, an expansion of the existing SWI is a critical and indispensable theme for South Africa as it attempts to bridge the infrastructure backlog (DWS, 2017c) to ensure the provision of adequate water services as enshrined in the South Africa Constitution, Act 108 of 1996. In ensuring the citizens' constitutional water access rights, the National Water White Paper of 1997 provides guidelines on the formulation of various pieces of legislation that explicitly emphasise the strengthening of water provision to the communities. Therefore, considering such a sound legal framework governing the delivery of water services against the backdrop of infrastructure deficiency, it is apparent that a gap exists in the literature in addressing the impacts of SWI factors on IWM and it remains unexplored. Hence, this study seeks to establish how SWI factors influence IWM under the current legal framework governing water management in South Africa.

Despite the well-crafted legal frameworks in regulating water transportation and distribution, South Africa's eight (8) metropolitan municipalities continue to experience severe WSDCs. SAMMs accommodate more than 22million people (Stats SA, 2016). However, much of the populace live in townships and informal settlements where disproportionally limited accessibility to a consistent water supply chain is rife. Additionally, the metropolitan municipalities have serious housing backlog problems that promoted temporary shelters in undesignated places, making it difficult and more expensive to design and develop water distribution channels. Although much of the people living in metropolitan municipalities have access to pipe-borne water in their yards, according to Braune, Adams and Fourie (2014), there is still a significant number of people who either have no access to piped water or access piped water in places further than 200m away from their yards. Notably, people living in informal settlements find it challenging to access water within the proximity of their yards. On the same note, people who live in townships have water taps either in their yards or inside their dwellings, but they can access water services for only limited hours. Thus, the disproportional distribution of water services and inconsistencies in water supply remains a bone of contention considering that metropolitan municipalities can generate more than 80% of the revenue from their fiscal activities (Republic of South Africa Department of National Treasury (RSADNT), 2018). Notwithstanding, the revenue generated by metropolitan councils in addition to government infrastructure grants and the ability to source equity from other financial institutions, SWI development projects remain underfunded and WSDCs are perpetuated. Therefore, it is expedient to investigate other factors that continue to derail efforts to close the SWI underinvestment gap.

Nonetheless, contributions by scholars have interrogated the direct and indirect influence of SWI factors on IWM in addressing WSDCs (Gomes, Alfinito & Albuquerque, 2013; Schweikert *et al.*, 2014; Chinowsky, Schweikert, Strzepek and Strzepek, 2015; Başci & Başci, 2016; Gomez *et al.*, 2019; Rivenbark, Fasiello & Adamo 2019). However, most of these studies have extant literature on the relationship between SWI factors and IWM, with some producing both negative and positive outcomes. Besides, the results from scholars revealing many challenges albeit separately, including climate change, an SWI funding gap, lack of appropriate skills, funding inaccessibility, and ageing infrastructure (Rodriguez *et al.*, 2012; Spaling, Brouwer & Njoka, 2014; Samuel *et al.*, 2016). Despite the vast literature in this subject area, no specific study examined the aggregated effects of SEGE factors on IWM in the context of SAMMs.

In the context of studies done in South Africa, the literature on this notion shows disagreement (Maclean, 2015; Maphalla, 2015; Makhari, 2016; Harding, 2017; Morudu, 2017). Studies produce both positive and negative outcomes. However, most studies focused on investigating WSDCs in municipalities. From the literature reviewed, a lack of funding contributes immensely to WSDCs (Infrastructure Dialogue, 2015). Moreover, the water sector's funding gap has constrained the expansion, upgrading and maintenance of SWI projects (Ruiters, 2013).

Chetty and Luiz (2014) blamed weak governance and a lack of human capital with technical skills as being the other contributors to WSDCs. Likewise, other studies decried WSAs for implementing an ineffective pricing model, making it impossible to recover full water cost (Madumo, 2015; Ruiters & Matji, 2015). Additionally, excessive non-revenue water (NREWA) is estimated to be above 35% contributes to an annual economic loss of R7billion (Mckenzie, 2014). Therefore, in pursuit of approaches to address WSDCs, this study sought to adopt a new approach regarding IWM as an instrumental factor in managing both sustainability factors and efforts to address WSDCs.

From the synthesis of the literature, it is evident that there is insufficient evidence to suggest that available studies are focusing on SWI factors and IWM in SAMMs. Although the South African government continues to increase funding to close the existing SWI underfunding gap, the desired results are still far from being achieved. Therefore, a departure from the business-as-usual approaches is required to address investment in SWI management without necessarily focusing only on increased funding. Hence, this study employed the Ordinary Least Squares and the Feasible Generalised Least Squares to examine the relationship between SWI factors (SEGE factors) and IWM in SAMMs. The study's motivation is to develop a coherent framework for SWI management that considers SEGE impacts on IWM.

1.3 RESEARCH AIM AND OBJECTIVES

1.3.1 Aim of the study

To examine the relationship between SWI factors and investment in water management in South African metropolitan municipalities.

1.3.2 Research objectives

Given the study aim above, the study aim is further expanded into sub-objectives as follows:

- Determine the relationship between corporate governance practices and investment in water management in South African metropolitan municipalities.
- Examine the relationship between environmental management practices and investment in water management in South African metropolitan municipalities.
- Evaluate the relationship between social practices and investment in water management in South African metropolitan municipalities.

- Evaluate the relationship between economic practices and investment in water management in South African metropolitan municipalities.
- Develop a framework for sustainable water management for improved investment in water management in SAMMs.

1.3.3 Research hypotheses

This study examines the relationship between SWI factors and IWM in SAMMs. The quest to address WSDCs influenced the researcher to focus on the impacts of social, economic, governance and environmental (SEGE) factors on IWM. The extant literature on this notion suggests that SWI factors have had a positive or negative influence on IWM, and hence the quest to understand the relationship remains. Therefore, the main hypothesis of this research points out that there is a positive relationship between SWI factors and IWM in SAMMs. To understand how various SWI factors influence IWM, the main hypothesis is expanded into sub-hypotheses as follows

- H_1: There is a positive relationship between corporate governance practices and investment in water management in South African metropolitan municipalities.
- H_2: There is a positive relationship between environmental management practices and investment in water management in South African metropolitan municipalities.
- H_3: There is a positive relationship between social practices and investment in water management in South African metropolitan municipalities.
- H_4: There is a positive relationship between economic practices and investment in water management in South African metropolitan municipalities.

1.4 METHODOLOGY

The researcher adopted the most appropriate research methodology to address the research inquiry in this study. In explaining the research model adopted, the researcher referred to Saunders, Lewis and Thornhill's (2012) research approach, which describes research elements as layers of an onion. The research adopted epistemology as a research paradigm as the researcher acknowledged that knowledge about the research inquiry is independent of values and moral content that characterise the world. The researcher considered positivism as the philosophical approach appropriate for the study because it is mostly associated with numerical data collection (Easterby-Smith, Thorpe & Lowe, 2002). Additionally, it involves developing new theories through the testing of existing theories (Saunders, Lewis, Thornhill & Bristow, 2009a). Furthermore, the study utilised the deductive approach in identifying related theories, which provided the foundation for formulating the research hypotheses to confirm or refute the same theories (Ngulube, Mathipa & Gumbo, 2015), thus, paving the way for the development of new theories.

The researcher examined the relationship between SWI factors and IWM in SAMMs. Thus, the study used the explanatory research design, which involved establishing correlations between the variables. Similarly, because the study used secondary data, a quantitative approach as suggested by Creswell (2009) saved time and cost; besides, it is reliable and less subjective. The researcher considered all 278 municipalities in South Africa as the study population. However, the researcher considered specific factors such as data availability, time, size of the municipality, revenue-generating capacity, population size and cost in deciding on a sample of eight (8) metropolitan municipalities in South Africa purposively selected.

The researcher collected historical secondary data from 2009 to 2019 from various internet-based data sources managed by various organisations, including municipalities, National Treasury's municipal finance data website, Statistics South Africa (Stats SA) census data and the South African Local Government Association (SALGA). Using content analysis as a data collection technique regarded as convinient and is often known for saving time and costs. The study used a total of ten independent variables (including two (2) control variables) and three (3) dependent variables.

Eviews and Stata were used to perform univariate, bivariate, and multivariate analysis in analysing secondary data for the study. The univariate analysis produced descriptive statistics including mean, mode, median, standard deviation and trend analysis for each of the variables representing SEGE factors and IWM. Additionally, the bivariate analysis produced results on the pairwise correlations to confirm multicollinearity between variables. Furthermore, the researcher evaluated the relationship between more than two (2) independent variables against the dependent variable using multivariate analysis. Since the study employed the panel data analysis, multiple linear regression models were employed to examine the relationship between SWI factors and IWM in SAMMs. However, in ensuring that the econometric models employed in this study hold, diagnostic tests were undertaken, including multicollinearity, serial correlation, heteroscedasticity, and normality. Based on the adequacy tests done, the researcher confirmed that the panel data analysis faced no threats emanating from data misspecifications that could have created bias to the results. Finally, the study applied panel regression estimators on panel data, namely Ordinary Least Squares and Feasible Generalised Least Square (FGLS) to examine the relationship between SWI factors and IWM in SAMMs. The need to improve the robustness of the models' results influenced the study to employ OLS and FGLS in examining the relationship between SWI factors and IWM because the two (2) approaches have different strengths and weaknesses.

1.5 SIGNIFICANCE OF THE STUDY

In the South African context, WSDSs' transformation to sustainable city initiatives is yet to be realised. This study fills the literature gap because it has great potential to influence WSAs by applying different approaches to address WSDCs. Besides, it is apparent that without water as the oil of the 21st century, the dream of realising sustainable cities remains far from being achieved, and as such, this study is significant in that it enlightens WSAs about water investment potentials lost due to failure to address some of the SEGE factors. More importantly, SAMMs, WSAs, water boards, catchment management agents, policymakers in water management, water consumers, environmentalists and DWS can align policies, guidelines and legislation in response to how SWI factors could either enhance IWM or derail efforts towards increasing investments.

The narratives surrounding the development of sustainable cities (SDG 11) make this study significant. It provides timely information on alternative ways of dealing with a long-standing SWI underinvestment gap by taking into cognisance water investment opportunities that could arise from adhering to good SEGE practices. Basically, with growing SWI underinvestment, the information provided by this study influences the WSAs to adopt bottom-up rather than top-down water management approaches, which allow the entire group of water sector stakeholders to voice their concerns regarding SEGE practices and ways of addressing WSDCs. Additionally, the bottom-up approach provides opportunities for water users to be vigilant and accept responsibility for social practices that could harm the functionality of WSDSs. Besides, assuming accountability and accepting responsibility allow water users to control social practices that result in vandalism, water theft and promoting corruption.

Furthermore, this study is significant because it closes the literature gap about water issues in the South African context and the world at large. The researcher regards this study as a significant project in the South African water sector. Hence, its significance to the scholars cannot be contested as it has opened a new way of confronting WSDCs, which could be employed in future empirical researches. Lastly, the study is expected to bring about a paradigm shift in understanding that not only increasing IWM could be the only sustainable and lasting solution to the prevailing water supply inconsistencies without addressing poor SEGE practices. Furthermore, it is vital to consider that various SEGE practices might have the potential to either derail water investment efforts or enhance progressive efforts towards creating a stable water investments environment and, as such, a sustainable, balanced IWM approach should be taken into consideration.

1.6 THE SCOPE OF THE RESEARCH

The study was limited to eight SAMMs. No other issues were considered beyond the scope of this study sample. On the other hand, the study could have considered many variables on each dimension relating to SEGE factors. However, because of data availability, only two variables of each category were considered in addition to two dependent variables representing IWM. The study is limited to eleven years (2009 to 2019), and the inception of Municipal Finance Management Act (MFMA) (Act 56 of 2003) influenced this decision.

Consequently, most municipalities fully complied with the reporting framework some years after MFMA's inception in 2003. Hence, the researcher decided to use 2009 as a base year for the study, and besides, data before 2009 are not readily available. Data from accredited sources were used with quantitative content analysis as the sole data collection technique. In terms of data analysis, Eviews and Stata were used to perform two linear panel data regression tests/techniques/estimators, namely OLS and FGLS. Despite generalisation being limited to SAMMs, the study results reflect to a certain extent a real phenomenon related to the various impacts of SEGE factors on IWM as all municipalities in South Africa are controlled by the same legal system. Therefore, the applicability of the proposed framework for guiding municipalities in dealing with SWI factors inhibiting the IWM effort is relevant to all cities facing similar WSDCs in South Africa.

1.7 LIMITATIONS OF THE STUDY

This study focused on examining the relationship between sustainability factors and IWM in SAMMs. The study only considered eight (8) metropolitan municipalities out of 278 due to the data's availability. Despite the small sample employed by the study, the municipalities' sizes in five different provinces mattered most in generalising the study results across South African municipalities. The study period of 11 years was not as long as the researcher would have wanted, but data availability was a constraining factor. Therefore, future studies should continue to explore this narrative as time progresses to gain deeper insights into the matter. Besides, the study variables used by the study change over time, and as such, the study results reflect the behaviours of the variables only during the study period. Hence, the researcher recommends further research relating to this field of study. According to the researcher, the study was the first one in the context of South African municipalities; hence the availability of extant literature was one of the limitations, which the researcher attempted to overcome by making references to related empirical studies that have used variables that are closely related to the ones in question. Lastly, there was no common database from which the data for the study were accessed. The researcher had to rely mostly on data accessed from the National Treasury of South Africa and the South African Local Government Association that provided half of the data. The rest of the data were sourced from multiple sources. In ensuring the reliability of the data, the study relied on data source validation.

1.8 CHAPTER LAYOUT

The thesis is composed of five chapters as follows:

Chapter One

The introductory chapter discusses the background of the study and presents the problem statement. This is done to establish the research gap. The chapter further defines the research aim, objectives, and hypotheses. The chapter also provides a brief discussion of the methodology employed in the study and the significance of the study, the scope of the study and the limitations of the study.

Chapter Two

The chapter presents a discussion on the context of the study, SWI and Agenda 2063. The chapter also discusses relevant theoretical perspectives, including the theory of infrastructure-led development, theory of public infrastructure, infrastructure as system theory and the sustainability imperative. Furthermore, the chapter delineates the regulatory framework governing water services provisioning in South Africa. This chapter elucidates the WSI needs in South Africa and various barriers to WSI. The chapter further discusses the related literature on the investment case for corporate governance, environmental, social, and economic factors before discussing the conceptual framework.

Chapter three

The chapter explains the research method employed by the study. All the research process stages are discussed, including the research philosophy and the paradigm, research method, and strategies. Additionally, the chapter looks at population, purposive sampling, and justification for selecting the unity of analysis. Furthermore, data sources, the method of data collection and the nature of the data collected are given under this chapter. The chapter also discusses data analysis techniques that include univariate, bivariate and multivariate methods. Finally, panel data econometric models, diagnostic tests, validity, and reliability checks are outlined in this chapter.

Chapter four

Based on the research hypotheses, the chapter discusses the main research results. The research results are composed of univariate, bivariate and multivariate analysis results. Additionally, the chapter presents the results from diagnostic tests and panel data econometric model estimators and the discussion of the results. Lastly, the chapter discusses a proposed framework for sustainable water management for improved investment in water infrastructure in SAMMs.

Chapter five

Chapter five presents a conclusion and recommendations based on research results. The chapter presents a discussion on the achievement of objectives, contributions of the study to the body of knowledge. Also, the chapter provides suggested recommendations for further studies. Lastly, the chapter presents the conclusion of the study.

1.9 SUMMARY OF THE CHAPTER

The chapter presents a discussion on the introductory background and the research problem. The chapter further delineates the aim of the study, objectives and hypotheses. It provides a short account of the research methodology adopted by the study to address the research inquiry. Also, it explains the significance and scope of the research and the structure of the thesis. The next chapter presents a discussion on SWI, Agenda 2063, theoretical framework and legal framework governing water services provision in South Africa. Furthermore, the proceeding chapter delineates WSI needs in South Africa, barriers to IWM and a review of the related literature concerning the relationship between SWI factors and IWM.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

The previous chapter presented an introductory background to the study, the problem statement, objectives, hypotheses, and a brief discussion of the methodology employed. This chapter presents a review of the literature on various issues relating to SWI. Section 2.2 provides a discussion on the context of the study concerning sustainability factors and IWM. Section 2.3 provides an insight into the understanding of SWI. Section 2.4 elucidates Agenda 2063, which is an African founded sustainable development road map. Section 2.5 provides a detailed discussion on sustainable infrastructure theories such as the theory of infrastructure-led development, theory of public good, infrastructure as system theory and the sustainability imperative. Section 2.6 and 2.7 elaborate on the regulatory framework governing water provision in South Africa and strategic plans, respectively.

To maintain coherence in this discussion, Section 2.8 and 2.9 of this chapter look at water sector needs in South Africa and barriers to WSI, respectively. Section 2.10 discusses the general relationship between SWI factors (SEGE) and IWM. Subsequently, sub- Sections 2.10.1-4 provide an empirical evaluation of the relevant literature concerning the relationship between each SEGE practices and IWM. Section 2.11 provides a discussion on the conceptual framework for the study. Finally, Section 2.12 provides a summary of the chapter.

2.2 BRIEF CONTEXT OF THE STUDY

Sustainable infrastructure plays a pivotal role in water harvesting, reticulation, allocation, and distribution to all places around cities (WWC, 2016). Water is critical in enhancing the sustainability, suitability, and liveability of cities worldwide (SACN, 2016). The prevailing inconsistencies in water supply in the cities have created panic amongst the various governments across the globe as challenges linked to unprecedented population growth, climate change, and the impending SWI underinvestment gap continues to have adverse effects on water supply infrastructure capacity (WSIC) (Butler *et al.*, 2016). Additionally, the SWIF across the globe is characterised by heterogeneity, with some places experiencing extreme water problems, which require considerable investments to mitigate their impacts on water services provision (Corfee-Morlot, 2016). However, the prevailing worldwide water service delivery challenges (WSDCs) are influenced by the country-specific social, environmental, governance, and economic (SEGE) practices that tend to affect the functionality of SWI (Butler *et al.,* 2016). In response to WSDCs, the national government and local municipal authorities are working around the clock to seek solutions to the pending water crisis in cities (Parks, Mclaren, Toumi & Rivett, 2019). Hence, there is a need to gain deep insights into ways to manage SWI factors and WSI.

In South Africa, the national government and municipalities are responsible for water provisioning throughout the country (CRSA, 1996). The responsibility to deal with repairs and maintenance of water infrastructure that transports water from water boards to the consumers lies with the municipalities. Through the DWS, the national government oversees the water supply value chain across the country. Similarly, the DWS is responsible for providing conditional water infrastructure grants to all municipalities to improve SWIF across the country (DWS, 2017a). To ensure commitment, the South African government put forward a sound and coherent legal framework that compels WSAs to fulfill the legal obligation of providing water services to the consumers without compromising.

Despite the government's efforts, WSDCs still exist as the country's clean water access rate is almost 88.2% (Stats SA, 2019), whereas the CRSA (1996) stipulates that every citizen has a right to clean water. This further indicates that a handful of people are struggling to access safe drinking water. In pursuit of SDG (6&11) and Africa Agenda 2063 (Goals 1 &7), the South African government has made progress towards improving SWIF across its eight (8) provinces (Hollingworth *et al.*, 2011). The idea of channelling more funding towards improving SWIF ensures every citizen access clean water, but the government is failing to meet the water market equilibrium (Infrastructure Dialogue, 2015). Notwithstanding the impacts of investment in SWI on water provisioning, WSDCs still exist. The critical question is whether the continued increase in IWM could be the only solution to the WSDCs or are there other exogenous factors that need to be addressed simultaneously to match the increasing IWM. This also implies that increasing the investment in the water sector may not be the only solution to address WSDCs. Given the gap between water demand and supply, it is fundamental to investigate how sustainability factors (social, economic, governance, and environmental) influence the IWM. Therefore, the study focuses on sustainability factors that have proved to have the potential to influence the level of IWM required to address WSDCs. The researcher assumes that the current instabilities in the WSI environment are due to failure by municipalities to address sustainability factors to enhance investment potentials. To further understand the discussion, the study provides insights into the understanding of SWI.

2.3 UNDERSTANDING SUSTAINABLE WATER INFRASTRUCTURE

The growing need to balance the ecological environment and developmental needs gave birth to the concept of sustainability. Sustainability refers to the capacity for continuance (Amasuomo, Hasnain & Osanyinlusi, 2015). Accordingly, Alhaddi (2015) points out that sustainability is an activity that focuses on providing equality to economic, social and environmental domains without compromising the future generation's needs. Sustainability efforts/actions should aim to achieve sustainable development, which Brundtland (1987) defined as the ability to balance the needs of the present generation without compromising the future generation's needs. In the context of sustainable development, sustainability refers to any effort aimed at seeking a balance among social, environmental, economic, and institutional factors in achieving sustainable development (Ashby, 2015). For this study, sustainability refers to actions seeking to balance social, economic, and environmental dimensions to achieve sustainable development. Concerning water infrastructure, sustainability is the quality of achieving the right level of sustainable development by ensuring that the right quality and quantity of water services are in a continuous supply without compromising water security.

According to IADB (2018), sustainable infrastructure refers to the infrastructure projects designed, planned, decommissioned, and operated to ensure economic, environmental, social, and institutional sustainability throughout its life span. Similarly, water infrastructure is sustainable when benefits accrue from its continued use over a long time after initial investments without interruptions (Spaling *et al.*, 2014). Ramboll Environ US Corporation (REUSC) (2017) explains that special consideration must be given to the construction of grey infrastructure and green infrastructure to contain the effects of climate change-induced risks that affect the functionality of SWI. Therefore, without a paradigm shift from business-as-usual approaches to the development of SWI in the urban areas, the possibilities of achieving the required level of infrastructure investment necessary for improving water security may remain unrealised.

According to Phimphanthavong (2014), SWI satisfies social, economic and environmental needs. Interlinkages and interdependencies between the dimensions of sustainable development are critical to achieving sustainable development (Figure 2.1).

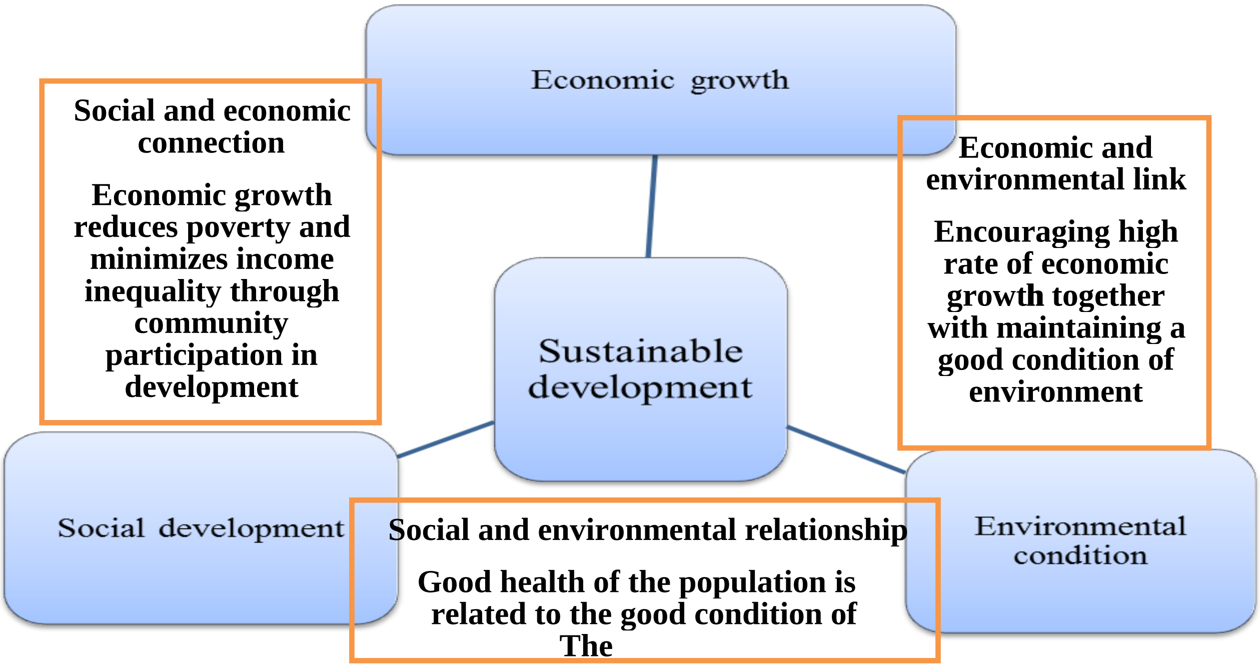

Figure 2. 1: Pillars of sustainable development.

Source: Phimphanthavong (2014: 101)

The effectiveness in delivering water in cities occurs when the construction of SWI follows sustainable development principles. However, this implies that society, the economy and the environmental needs should provide a foundation upon which planning for development infrastructure is based (Phimphanthavong, 2014). Similarly, the whole idea of sustainability in the development of infrastructure in cities is to achieve compatibility among various sustainable development dimensions to ensure that water and air pollution problems cease to continue threatening the efforts towards achieving SDGs. On the same note, addressing pollution problems promotes resource efficiency and equitable service delivery in cities (Corfee-Morlot, 2016). Therefore, SWI in the context of water provisioning in cities should enable the water supply chain to function efficiently and effectively without disruptions. Hence, without adopting sustainable development and African Agenda 2063 guidelines in building SWI, water security in cities may remain questionable, as the lack of water sector investment continues to widen the underinvestment gap.

2.4 THE AGENDA 2063

The Agenda 2063 was found in 2013 by the African Union. The political leadership of Africa came up with an African context-based strategic framework to promote inclusive growth and sustainable development. According to Ndzendze and Monyae (2019), the African Union's Agenda 2063 has many linkages with the UN's SDGs. However, the only difference is that Agenda 2063 is a context-based sustainable development road map based on Africa's development challenges, and UN's SDGs are based on global context. Similarly, Agenda 2063 is people-driven development plan, outlining the "Africa we want" narrative. The African Union Commission's (2015:11) Agenda 2063 outlines eight (8) key areas in the forms of aspirations, which contain yardsticks to measure them. These are as follows:

- Inclusive growth and sustainable development
- An integrated continent politically united based on the ideals of Pan-Africanism
- Promoting good governance, democracy, human rights and the rule of law
- A peaceful and secured Africa
- Strong cultural identity, shared values and ethics and common heritage
- Achieving people-driven development that caters for women, youth and children
- Working towards achieving a robust, resilient and united Africa which competes globally

The aspirations provide an overview of Africa's direction as a continent is trying to achieve an integrated, prosperous and peaceful Africa. The availability of water in Africa ensures the achievement of Africa Agenda 2063. In terms of infrastructure development, the first ten-year implementation plan by the African Union spells out strategies for achieving the desired economic growth levels (Ndzendze & Monyae, 2019). Notwithstanding the contribution of Agenda 2063, sustainable infrastructure projects (SIPs) remained confined because of a lack of funding, which has continued to impede the successful development of integrated management water systems.

To show Africa's commitment towards addressing water security issues, Agenda 2063 set goal 1, which identified the development of modern and liveable habitats and the provision of quality services. Additionally, Goal 7 focuses on water security as one of the priority areas in Africa. In the context of this study, goals 1 and 7 are wholly linked to the aim of the study, which focuses on addressing WSDCs in South Africa's growing cities. Given the efforts towards addressing the water supply gap, Africa's roadmap to sustainable and inclusive growth targets the reduction of the population without access to safe drinking water by 95% in 2023 (The African Union Commission, 2015). In attempting to achieve such a target, African countries are encouraged to develop their country-specific frameworks on water and sanitation, including water efficiency plans, water sector policy, and water and sanitation evaluation reform systems. However, Kganyago and Mhangara (2019) posit that African countries lack robust strategies to achieve Agenda 2063 due to the failure to gather adequate data to monitor progress. Given the views of the above authors, without addressing all challenges relating to sustainable water management, the "Africa we want" narrative remains an unattainable idea. Understanding how Agenda 2063 can influence water provisioning efforts through proper management of sustainability factors and water sector investment, the study introduces related SWI theories.

2.5 THEORETICAL FRAMEWORK

Sustainable water infrastructure (SWI) and investment in water management (IWM) are some of the core factors which determine the effective and efficient delivery of water services in cities (Ruiters, 2013). This narrative has a long history in the sustainable development discourses and is characterised by theoretical analysis and empirical studies. According to Grant and Osanloo (2014) and Rockinson-Szapkiw (2017), the theoretical framework provides a ground base from which knowledge is constructed when developing a literature review. Adom, Hussein and Agyem (2018) suggest that incorporating the theoretical framework in a thesis is a mandatory requirement as it provides a clear research road map, which leads to a proper investigation. In conceptualising and contextualising the ideology of sustainability about the management of water investments, different theories are incorporated in this discussion to gain deep insights into and clear understanding of the sustainable development approach that impacts the proper functioning of sustainable water management. The present study presents four (4) main theories of infrastructure development; these are a theory of infrastructure-led developement, the theory of public good, the sustainability imperative and infrastructure as system theory. These four (4) theories are essential to this discussion because they all share the aspects of promoting sustainable development and complementarity, critical in providing direction and impetus to the research inquiry in question.

2.5.1 Theory of infrastructure-led development

Infrastructure comprises the physical assets that facilitate services such as transport, electricity, gas, water supply, sanitation, sewerage, and communication in any defined area (Estache & Garsous, 2012; Younis, 2014). Sustainable infrastructure is a driver of the economy as Bourne and Zuluaga (2016) contend that state-led infrastructure investment is an excellent economic growth stimulus, mainly where market failures are prevalent. In the context of water services provision in cities, infrastructure is key to water harvesting, storage, reticulation, purification, transportation, and distribution. Therefore, the theory of infrastructure-led development is an indispensable issue to cities' growth through the development of SWI to ensure adequate water supply. Agénor (2010) proposed a long-run development theory based on public infrastructure as an engine of growth. The theory stresses that infrastructure development dramatically affects the productivity of every sector of the economy by addressing challenges relating to employment, provision of services and degree of infrastructure efficiency in local areas. On the same note, the demand-side theory of infrastructure complements the theory of infrastructure-led development by advocating for the human desire to realise the value in using infrastructure, which is perceived as a propeller of infrastructure development in all parts of the world, particularly in cities where sustainable infrastructure has become a necessity in promoting sustainable growth (Frischmann, 2004). Therefore, focusing on the development and improvement of sustainability water is an attempt by cities' management to acknowledge that infrastructure-led development ideology can stimulate the economic growth required for transforming underdeveloped urban areas into sustainable cities.

Development of infrastructure is a long-term project and requires a substantial amount of funding as prevailing social, economic, environmental, and governance factors continue to evolve, therefore, it causes uncertainties to the proper functioning of the infrastructure (Inter-American Development Bank (IADB), 2018). Globally, the development of infrastructure is coordinated and decided upon by the various organs of the state, including local, provincial, and national governments. The state's involvement in developing infrastructure has a long history in the literature (Bourne & Zuluaga, 2016). Historically, state-led infrastructure investment spending is linked to the British economist's proposition, John Maynard Keynes who encouraged the government to adopt the Keynesian economic theory to confront the negative impacts of the Great Depression in the 1930s. The Keynesian economic theory calls on the government to increase spending on infrastructure during low economic growth to create employment opportunities with the idea of creating a multiplier effect on the economy.

Contrary to the common view about the government's intervention in running the economy, Karl Max argued that government interference presents extreme conditions that prevent economic activities' free flow. Meanwhile, the belief is that free trade, private property, and competition are the foundations to spur economic development, reduce poverty, and bring in humankind's social and moral improvements (Dang & Pheng, 2015). Therefore, because water is a basic need, the government must provide everything required to make it accessible without compromising economic progress (White, 2015).

However, it is not a matter of overinvestment or underinvestment in state-sponsored infrastructure projects, as the narrative of economic sustainability of infrastructure has become a contemporary theme in sustainable development discourses (IADB, 2018). Bottini, Coelho, and Kao (2013) posit that apart from overinvestment in infrastructure as an area of significant concern, the quality of infrastructure investment is essential in ensuring high marginal returns. Failure to effectively plan for infrastructure development could raise the chances that fiscal profligacy might occur, leading to disastrous consequences (Ansar, Flyvbjerg, Budzier & Lunn, 2016). However, the building of sustainable water management is beyond the control of private individuals, and in most cases, particularly in developing countries, the political system often prioritises the investment of infrastructure to gain electoral advantage instead of delivering infrastructure, which will deliver economic growth (Bourne & Zuluaga, 2016). Given the context under which the state uses infrastructure development projects as a political tool, Gurara, Klyuev, Mwase, Presbitero, Xu and Bannister (2017) reiterate that to achieve public investment efficiency and effectiveness, it is imperative to put in place appropriate institutions and policies which govern the development of sustainable infrastructure. Hence, given the significance of the theory of infrastructure-led development in adopting infrastructure development policies, the national government may use the same approach in ensuring the achievement of goals in line with SDGs (6 &11) and Africa Aspiration (#1) for Agenda 2063 (goal 1 &7).

While acknowledging that adequate investment is an essential determinant in advancing the theory of infrastructure-led development when embarking on SWI projects (ADB, 2017), many other factors should be considered in building a network of infrastructure that would offer best services. For cities to be sustainable and liveable, the functionality of SWI must be effective and efficient to address the current and future water needs (DWS), 2017c). State-initiated SWI projects are essential in ensuring that water security improves in the cities. Water and sanitation aid to improve productivity and, therefore, propel economic growth, which will generate enough revenue to finance sustainable cities projects (Agénor, 2010; Estache & Garsous, 2012). Water as an essential resource for the achievement of SDG 6 (Makhari, 2016), and any impediments to its provision in the cities should be confronted with significant opposition. Unless more emphasis is placed on sustainability factors to influence the level of IWM, the application of theory relating infrastructure-led developement is not expected to influence the provision of water services in the cities positively. Therefore, it is plausible that sustainable water provisioning may lead to economic growth and development in metropolitan cities.

2.5.2 Theory of public good

The public good theory suggests that public goods are non-rivalrous and non-excludable, and collectively consumed as postulated by Paul Samuelson in 1954. Samuelson (1954) proposed that the concept of public consumption, which gave birth to the term "pure public good" provides a clear distinction between public and private goods. Pure public goods are collectively consumed without disadvantaging other consumers. Looking at the theory of public good in the context of water and SWI, there is a link between the declaration made by the United Nations regarding water and sanitation as a fundamental human right by classifying water as a public good and water access as a constitutional right in many UN-member states (White, 2015). Bakker (2003) suggests that water has strategic political and territorial significance with no substitutable resources. Lee and Floris (2003) pointed out that water is a basic need with no close substitute, and the principle of affordability to everyone cannot be overemphasised. However, water in its various forms is unique because it shares the features of private, marketable and fundamental human rights. Therefore, it is not clear whether to categorise water as a private or public good (White, 2015). Divergent views on whether water should be classified as a public good continue to create controversies. For instance, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in 1992, took a flipped decision by anonymously agreeing to the fact that the only way to eliminate problems relating to poor water governance is by treating water as an economic good (International Institute for sustainable development (IISD), 2012).

Contrary to the above, Steurer (2008) posits that commodifying water services would economically restrain the government from providing potable water and sanitation services to poor households. Classifying the production of water, which is characterised by inherent positive and negative externalities, makes it difficult to fully commodify its associated costs with negative externalities that cannot be individually absorbed. Hence, negative externalities generated by water production can provide a basis for classifying water as a public good (Bakker, 2003). In this study, the researcher has taken the dimension of sustainable water management as a public good because of the non-excludability feature associated with these two (2) aspects. Hence, considering conflicting views regarding water as either economic or public good, the government's involvement in the construction of sustainability management of water sector involvement remains relevant.

Additionally, in providing clarity on applying the theory of public good in this discussion, White (2015) shares deep insights into the narrative by illustrating the context under which water should be classified into the two (2) categories as shown in Figure 2.2.

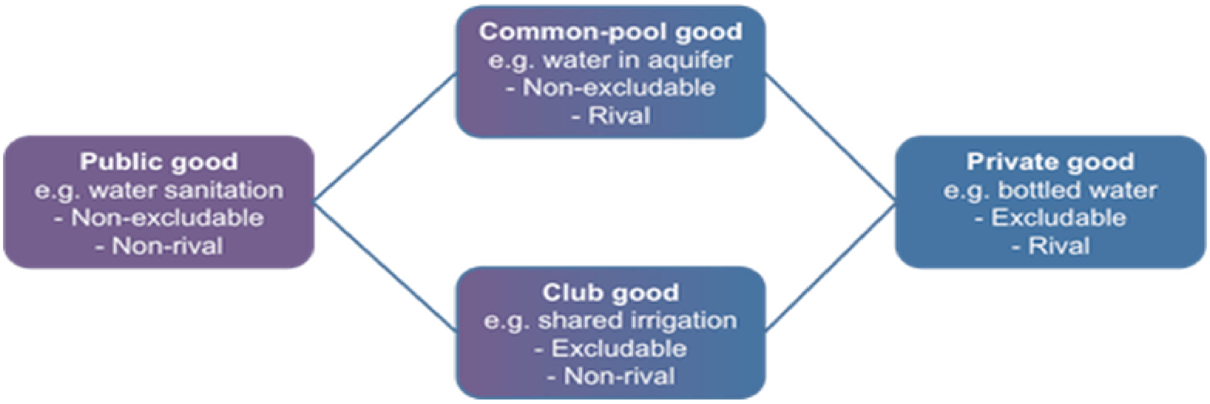

Figure 2. 2:Water a public and private good

Source: White (2015:7)

As shown in Figure 2.2, water is not defined as a private or public good because it shares some features of both. Similar claims have been made by Mader (2011) who suggested that the difference between public and private good is socially constructed, implying the many factors considered in categorising the precious resource as either a public or economic good. While water in the reservoir is a private good, the water reservoir's storage capacity as per se may be a public good (Hanemann, 2006). According to White (2015), once the value is added to water, it becomes a commodity, which attracts reasonable prices. On the same note, commodifying water is likely to lead to market failure since its allocation might favour those who can afford to pay for it (Mader, 2011; White, 2015). Hence, privatisation and commercialisation of water services come with undesirable consequences (Bakker, 2003). The existence of economically polarised communities makes it difficult to recover water costs as vulnerable poor households cannot pay for the services (Bond, 2003). Therefore, misspecifications on water pricing may be one of the reasons why the IWM gap remains unaddressed.

Contrary to the above argument, Lee and Floris (2003) argue that water supply security is assured when the real cost is enforced. Even though providing free water is compatible with the public good theory, it proves to be economically challenging. Hence, by examining the impacts of sustainability factors on IWM, there is a likelihood of addressing the challenges relating to water provision, since the public good theory influences the state to take full responsibility for ensuring the sustainable provision of water services system exists.

According to the United Nations Industrial Development Organisation (UNIDO) (2008), the quality of life and environmental sustainability have a strong link with public goods. The achievement of Sustainable Development Goals (SDGs) and Agenda 2063 aspirations relating to sustainable economic growth, peace and security solely depend on the adequate supply of public goods. Furthermore, by classifying water as a public good, everything linked to its provision and supply like sustainability water management falls into the same category. Fedderke and Garlick (2008) point out that infrastructure possesses a public good characteristic as the developer or owner finds it difficult to exclude others from using it. However, SWI is some of the under-provided resources in cities because of the many factors, such as the lack of funding and poor governance (ACBF, 2016). While water is a bulky resource, its transport infrastructure is expensive to build and maintain; hence, in most cases, the government is the sole investor (Samuelson, 1954). Government-owned infrastructure is socially owned; hence, the social contract to use the public infrastructure exists when it is open for use (Frischmann, 2004). Failure by the government to intervene in developing infrastructure would result in market failures as private organisations are not keen to provide public goods at prices affordable to poor households (Prud’homme, 2004). Therefore, the theory of public good attempts to identify and define specific components of sustainable water management as public goods and ensure that government provides special attention to factors impeding public utilities' proper functioning as a strategy in seeking prompt solutions to the WSDCs in cities.

2.5.3 Infrastructure as a system theory

Infrastructure as a system theory describes infrastructure as a network composed of interconnected elements which interact with other infrastructural elements (Ejigu, 2007). Fedderke and Garlick (2008) point out that interconnection between various components of infrastructure complements each other in their functioning, and failure of one component to function appropriately compromises the proper function of the whole system. Admittedly, the infrastructure's functioning follows a system-of-systems approach that considers cross-sectional interdependencies between infrastructure sectors (Mansoor & Williams, 2018). In line with conventional graph theory, the infrastructure system is defined as a collection of nodes, links, and edges representing the dynamic and complex nature of the system (Dudenhoeffer, Permann & Manic, 2006). Hall, Tran, Hickford and Nicholls (2016) define the infrastructure system as a compilation of integrated physical facilities and human systems that are coordinated to provide a particular infrastructure service. In this regard, infrastructure as a system theory considers the way the SWI system works. Infrastructure cannot work in isolation, as there is a need to complement other factors and inputs in the production process to deliver services (Fedderke & Garlick, 2008) effectively. For this study, infrastructure as a system theory attempts to identify various components of sustainability management that are required to be integrated and coordinated to achieve optimal production and delivery of water services in the growing cities.

When developing sustainable water management in cities, no single factor should be given more attention than others as a development process cannot be guaranteed. Mansoor and William (2018) stress that adequate planning should consider certain factors including future operation, socio-economic changes, capacity and environmental performance of the infrastructure systems, and economic growth when developing infrastructure. Additionally, they added that the systems of systems approach assist policymakers to identfy strategic infrastructure to ensure that optimal functioning of the entire infrastructure system is not compromised. For example, in urban planning, critical infrastructure provides a portfolio of services such as telecommunication, water, sanitation, transportation, and energy. Without any infrastructure resources, the whole infrastructure system will not optimally function; hence service delivery failures are expected. In avoiding the failure of infrastructure system in urban areas, Rehak and Hromada (2018) stress that planning an infrastructure system should involve collaboration and synchronisation of sub-systems to avoid economic, ecological, and social costs emanating from its use. This implies that urban planners have an essential role in ensuring that adequate urban SWI settings are put in place to address sustainability challenges emanating from the growing population in cities. Therefore, the adoption of the infrastructure as a system theory by the researcher has been informed by its effectiveness in providing a guideline for developing SWI that delivers unsurpassed water services in developing cities by taking social, environmental, economic and institutional factors into consideration.

Infrastructure as a system theory best explains how the various components of infrastructure interact to confront challenges emanating from social, environmental, economic and climatic spheres (Mansoor & Williams, 2018). In ensuring that the development of infrastructure is balanced, Nueman (2012) suggests that a demand-capacity management approach is imperative to making decisions regarding where, when and why infrastructure is needed to stimulate growth in the cities optimally. However, the demand-capacity approach eliminates problems relating to underutilisation and overinvestment of infrastructure in the cities. When developing SWI in cities, complementarity is a pre-requisite in the sense that infrastructure investment decisions should factor in the roles of individual components within an integrated infrastructure system in providing water services in cities. This should be done to avoid insufficient and excessive infrastructure investments, which might constrain the functioning of the infrastructure system and add no corresponding value to the system (Bottini *et al.*, 2013). In considering the dynamic climatic developments characterised by temperature variations and social-economic risks, Mansoor and Williams (2018) emphasised that a complementarity imperative should take centre stage in urban planning. As infrastructure systems are complex systems and are deeply embedded in society, economics and environmental spheres, infrastructure planning associated with complex decisions should consider all risks emanating from the sustainable development dimensions (Ejigu, 2007). Therefore, the researcher uses infrastructure as a system theory to analyse how various sustainable water management components interact within the system to provide the best portfolio of infrastructural services.

Infrastructure as a system theory further stresses that all the sub-elements of an integrated infrastructure system should receive the same level of attention regarding investment needs, innovativeness, and preparedness to confront climate, social and economic related risks. This is necessary because infrastructure elements complement each other in executing their functions; however, one component's failure will lead to the total collapse of the whole supply chain or system (Fedderke & Garlick, 2008; Mansoor & Williams, 2018). This is done to embrace the theory of coordination failure, which advocates for collaborative infrastructure components to be well-coordinated in all aspects to avoid the system from failing (Glăvan, 2008). For example, water leakages from the pipes will lead to economic losses and environmental-related health hazards, which might pose health risks to surrounding water consumers. Therefore, the infrastructure as a theory system will help city planners identify complexities and approaches to deal with uncertainties from the social, economic, institutional and environmental settings within the urban environment.

2.5.4 The Sustainability imperative

The Sustainability imperative is a balanced approach to building sustainable infrastructure which considers dimensions of capital, including economic, social, human and natural capital (Radej, 2007). However, the growing need to balance the relationship between development and environment has led to sustainable development narrative (Dang & Pheng, 2015). Sustainable development refers to the ability to meet both present and future generations (Brundtland, 1987). Amasuomo, Hasnain and Osanyinlusi (2015), on the other hand, describe sustainable development as the ability to balance economic growth and maintain and protect the good standard of environmental protection. By adopting a sustainability approach in building infrastructure, special considerations such as social and environmental compatibility should receive unabated attention as air and water pollution need to be significantly reduced (Corfee-Morlot, 2016). This implies that a balanced approach needs to be adopted in ensuring that the present and future demands are met without necessarily putting any generation at a disadvantage (Zhang, Lu, Zhao & Song, 2014). Furthermore, the interaction between development and sustainability continues to play essential role in creating awareness among policymakers and lawmakers in both private and public sectors. Additionally, similar calls have been made by Ashby (2015) who points out that in order to uphold the principle of sustainability, infrastructure development should consider balancing the attention given to economic, human development and economic prosperity as shown in Figure 2.3.

Figure 2. 3: Dimensions of capital

Source: Ashby (2015:70)

All three dimensions of capital are not mutually exclusive, but they are mutually embedded in each other as they work as collaborators towards achieving SDG. Therefore, it is imperative to ensure that optimal benefits accrue from the optimal use of a set of infrastructure mix. However, regarding the development of SWI in cities, special consideration should be given to all pillars of sustainability ensure the proper mix of capital dimensions is achieved in line with the principle of sustainable development (Amasuomo *et al.*, 2015). Therefore, it is plausible for urban planners to adopt sustainability imperatives that can overcome WSDCs in cities.

With the growing calls for sustainable development, urban development planning has taken a novel approach to developing infrastructure, by giving preference to sustainability issues (ADB, 2017). For this study, the sustainability imperative is adopted because the development of SWI requires the different dimensions of capital to be integrated to directly influence environmental sustainability, social equity, and economic efficiency (Bond, 2003). In encouraging and influencing sustainable infrastructure development that aligns to SDGs, policies and regulations should be put in place to ensure that the sustainability approach is adopted to develop infrastructure (Zhang *et al.*, 2014). In the context of SWI development, the sustainability imperative helps policymakers, developers, and regulators ensure that manufactured, human and natural capital are simultaneously given the same level of consideration as they complement each other to provide adequate water services. Therefore, without adopting an imperative sustainability approach, sustainable cities' creation remains a dream in the pipeline as improved water security remains a pre-requisite for the growth of cities.

The sustainability imperative proposes that a significant and robust relationship between all three dimensions of capital exist. Mell (2010) narrowed this proposition by stressing that there is the point of linear connectivity between built capitals, social and human capital, natural capital and viable ecosystem. Water infrastructure is composed of natural infrastructure such as dams and lakes (Hollingworth *et al*., 2011) and built infrastructure, which requires human beings' input for effective operation. On the same note, it is equally essential to ensure that innovative technology is brought in without necessarily upsetting the entire ecosystem; it should enhance the natural system. Therefore, the decision to incorporate the imperative sustainability approach in infrastructure development decisions is best informed by its potential to influence policymakers in achieving equality between dimensions of capital to avoid further damage to the eco-system. In simple terms, the sustainability imperative, if adopted successfully in the construction of the SWI, will ensure the desired co-existence between dimensions of sustainable development are achieved.

To further understand the management of water service provision and SWI factors, the next section discusses the legal framework defining the responsibilities of water utilities, municipalities, and water services authorities.

2.6 LEGAL AND REGULATORY FRAMEWORKS GOVERNING WATER SERVICES DELIVERY IN SOUTH AFRICA

The aftermath of democratic governance in South Africa was characterised by many changes to the governance of water services provision and water infrastructure management, to ensure that the citizens' rights to health and a safe environment are respected, promoted and protected (WWF-SA, 2016). Given the challenges relating to dams' safety, the failure to balance water supply and demand, and climate change impacts facing the water sector in South Africa, a healthy and quality regulatory environment is crucial in achieving water security. To ensure that water rights are not violated, the South African government has a coherent and broad set of legislation and frameworks that govern water and sanitation provision throughout the country (South Africa Institute of Engineers (SAICE), 2017). For this study, it is important to discuss relevant legislation, policies, regulations, and strategies (as shown in Figure 2.4) to gain deep insights into the effectiveness of the existing water governance framework in cities.

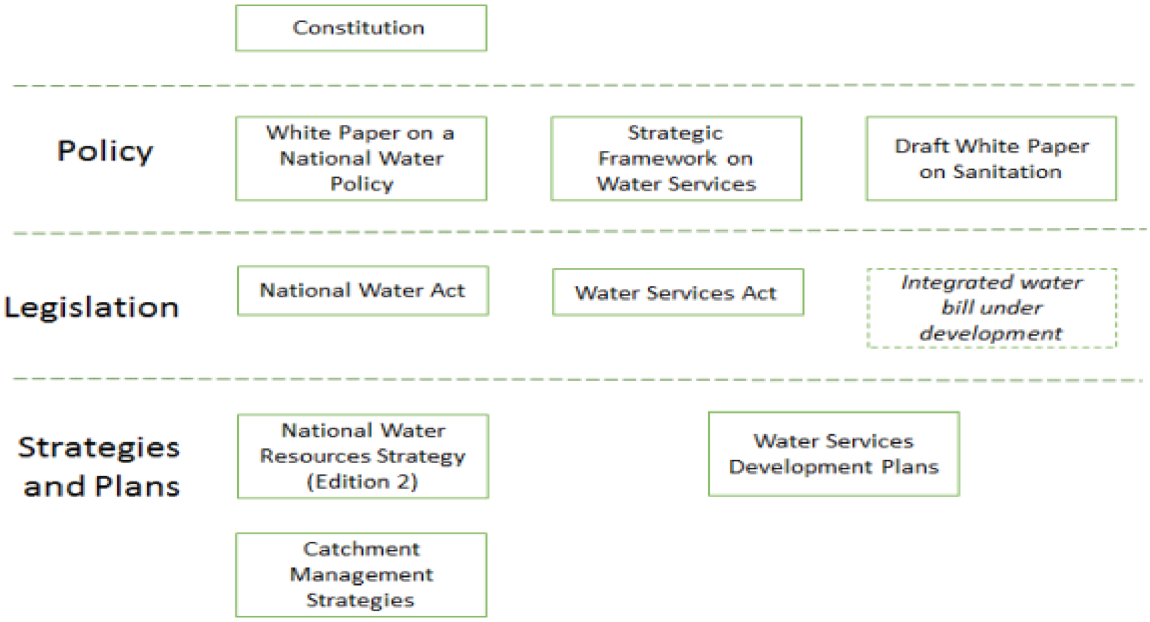

Figure 2. 4: The water sector policy and legislative framework

Source: WWF-SA (2016:5)

2.6.1 The constitution of the Republic of South Africa (CRSA) (Act 108 of 1996)

The CRSA clearly defines the mandate given to all role players in the water sector. The most influential water sector stakeholders are WSAs that provide direct water services to consumers. The five (5) objectives of local governments are highlighted in Section 152 of the CRSA as follows:

- Promoting local economic development.
- Encouraging local stakeholder's involvement in local government matters.
- Promoting a healthy and safe environment.
- Ensuring the sustainable provision of basic services.
- Providing a good governance system and promoting accountability and democracy.

As stipulated in the constitution, water service provision should be treated as a basic human right which should be uncompromisingly provided to the citizens in the right quality and quantity at the right times (CRSA, 1996). Similarly, in terms of 27(1) (b) of the Republic of South Africa's Constitution, all citizens have the right to enough water. Moreover, the state is mandated to adopt legislation, and other measures that ensure the water access rights are realised within the law. Part B of Schedule 4 of the CRSA provides executive and legislative authority to WSAs to provide water and sanitation without failure. In terms of section 7(2), the state through municipalities is constitutionally mandated to respect, promote, protect, and fulfil all the bill of rights requirements. Besides, municipalities are constitutionally mandated to manage issues relating to land use planning and the availability of infrastructure responsible for providing water and sanitation services (WWF-SA, 2016). Water as a component of the environment, and section 24 of the constitution states that water services must be adequately provided to maintain the ecological environment's functionality. In conjunction with the requirements of the CRSA, the NEMA (Act 107 of 1998) regards water as an environmental resource needed to sustain lives. Therefore, the CRSA provides a foundation upon which all water sector-related legislation and laws are formulated to promote effective WSDSs in cities. Hence without adherence to the requirements of the CRSA, WSDCs in cities are expected to persist.

2.6.2 The National Water Act (NWA) (Act 36 of 1998)

The NWA has been amended twice since it was promulgated by Act 45 of 1999 and by Act 27 of 2014. The NWA provides a legal framework for the management of water resources, including the distribution of water for beneficial use to various sectors of the economy. The NWA affirms the state’s public trustee role in national water resources. The NWA empowers the DWS to ensure that water resources are protected, developed, used, controlled, conserved, and managed in a sustainable, effective, and equitable manner by ensuring that a suitable governance institution is established (DWS, 2016).

2.6.3 The Water services Act (WSA) No. 108 of 1997.

The Water Services Act (WSA) was amended by Act 30 of 2004. In conjunction with NWA (Act 45 of 1999), WSA is the primary instrument dealing with accessibility and water services provision. WSA reaffirms the government’s position as an active player in water and sanitation services provision governance. As enshrined in this WSA Act 108 of 1997, municipalities are WSAs. Their fundamental responsibility to the current and potential water consumers is to ensure that efficient, affordable, economic, and sustainable water services access remains a priority within their jurisdiction. As prescribed in WSA Act 108 of 1997, sufficient quantities of water required to ensure the objective of a safe environment is achieved by setting national standards and norms, and see to it that effective water resources management and conservation receive priority when adopting water service development plans (DWS, 2016). In conjunction with section 27 of the CRSA, Section 3 of the WSA Act 108 of 1997, further stresses that water is a basic human right, that is, the state must put in place reasonable measures and empower various authorities to uncompromisingly provide the right quantity of water services. The legislation in addressing WSDCs in cities may be a critical factor in ensuring that the concept of building SSC is achieved.

2.7 STRATEGIES AND PLANS

The DWS established various legal framework-aligned strategies for managing water resources. These include NWRS, the National investment framework for the water sector and the National Raw water pricing strategy. These strategies have been put in place to ensure the efficiency and effectiveness of water services delivery in South Africa.

2.7.1 National water resources strategy

The NWRS was founded in 2004, and the revised version (NWRS2) was released in 2013. The goal of the NWRS is to ensure the efficient and effective management of water resources through equitable and sustainable growth and development (DWA, 2013). The NWRS acknowledges the fact that South Africa is a water-scarce country, facing corruption and funding challenges. Hence, the strategy ensures that the factors impeding progress on water services provision require implementation, as set out in the National Development Plan and the NWA. NWRS 2 was necessary because the current water resources are under pressure; this is against the backdrop of a vast SWI underfunding gap (DWA, 2013). NWRS 2 include the elimination of poverty and inequalities, the creation of employment, the promotion of economic growth, and ensuring that water resources are managed and protected sustainably. As such, NWRS is a fundamental tool for resolving WSDCs amicably.

2.7.2 National Water investment framework (NWIF)

The provision of adequate water services requires sufficient investment in the water infrastructure. The NWIF provides guidelines for the planning and managing financial resources within the water sector (van Zyl, 2011). The NWIF is a national instrument that spells out information on funds required for developing a sustainable water delivery system in the country. Given the existing SWI funding challenges in South Africa, NWIF provides an overview of funds required to meet water demands in South Africa. Therefore, the NWIF must address the challenges relating to IWM for improved water service delivery.

2.7.3 White Paper: National Water Policy

The government's position concerning the management of scarce water resources is set out in the 1997 White Paper. The comprehensive White Paper policy is placed in the context of the bill of rights of South Africa and considered with the country's socio-economic context. As enshrined in the CRSA, Section 27 (1) (b), the right to access sufficient water services is an incontestable constitutional right. The White Paper emphasises correcting past water distribution injustices, which prevailed during the pre-democratic era. The South African government expressed its commitment to addressing WSDCs through implementing the various policy proposals put forward in the White Paper. Since the establishment of the White Paper in 1998, improvement in water services provision is quite evident, as indicated in the 2016 census report that the water access rate improved to increased 96% during period 1994 to 2015 (Statistics South Africa (Stats SA), 2016). The White Paper ensures that various stakeholders work together to create a sustainable human settlement that provides a decent quality of life that recognizes the communities' socio-economic needs. Similarly, the White paper underscores' fundamental issues include promoting environmental sustainability, financial sustainability, effective and efficient use of resources, promoting transparency and good governance, and equitable distribution of resources. However, in the context of this study, adherence to the White Paper policy by WSPs ensures that all SEGE factors that affect SWI and IWM are brought to the attention of policymakers who ought to find solutions to WSDCs in cities.

Despite the coherent legal framework in place, the prevalence of WSDCs in many communities remains an obstacle to local economic development. However, this further confirms that existing legislation, policies, regulations, and strategies dealing with water service provision issues require alignment towards achieving the same objective of fighting WSDCs (DWS, 2017b). If inconsistences are not addressed, incoherences characterising water governance instruments may continue to threaten the functionality of SWI, which in turn has an impact on IWM. Therefore, failure to address policy framework governing water management issues might be a challenge contributing to an ever increasing water investment gap. Hence, it is imperative to address any threat to SWI to achieve a sustainable water supply system.

2.8 WATER SECTOR INVESTMENT NEEDS IN SOUTH AFRICA

Water investment is creating a portfolio of productive water infrastructure assets to yield direct and indirect income. Besides investing only in infrastructure, Singh (2014) argues that investment in water infrastructure is concomitant to institutional investment. Without strong water governance institutions, the water supply chain will not be effective and efficient in providing water services. Water has become the oil of the 21st century; hence, more attention should be channelled towards improving its security, mainly through managing WSI. Changes to WSI demands are driven by many factors, including industrialisation, unprecedented population growth, SWI underinvestment gap, and climate change. These factors have created water security fears by threatening the functionality of freshwater resources and SWI as evidenced by the prevalence of endless WSDCs (Van der Bruggen, Borghgraef & Vinckier, 2010; Allianz Global Investors, 2013; WHO, 2014). Apart from the factors mentioned above, Frone and Frone (2014) argue that changes in the socio-economic environment, the state of infrastructure, and governance issues such as policies and directives have continuously contributed to the worsening water security situation in the world. Hence, considering the need to keep investing in the water sector without improving the institutional capacity, achieving effectiveness and efficiency, managing water investment may remain a distant goal.

Furthermore, institutional incapacitation has resulted in multifaceted problems related to infrastructure neglected and high cost of operation and maintenance, and these problems continue to hurt SWI and IWM (United Nations (UN), 2015). Hence, adequate funding is required to meet all WSI needs and to achieve effective WSDSs. Given WSI needs, the European Bank for Reconstruction and Development (EBRD) (2019:15) highlights the fact that investments in water and wastewater infrastructure are needed to:

- Address service backlog and rehabilitate ageing infrastructure.
- Improve efficiency, reduce NREWA and unnecessary consumption.
- Create multifaceted water sources (for example, desalination and groundwater extraction).
- Implement climate adaptation measures and improve environmental compliance.
- Improve public health.

In light of the WSI's needs, the UN-Water and WHO (2017) global analysis and assessment (GLAAS) report on the 2016 WSI and investment framework in South Africa suggests that a total annual capital investment of about US$6.4 billion is required to meet the investment demand required for WASH throughout the next coming ten years. However, only US$3.6 billion is available, and this implies that US$2.8 billion represents an intolerable underfunding gap. Besides that, US$ 3.4 is required to fund the maintenance of existing SWI is in short supply. Against this backdrop, the DWS (2018) is in dire need of funds for refurbishment, upgrading existing SWI, and procurement of new assets to improving the existing water supply capacity to meet the population growth driven water demand. In the water sector, DWS provides a ten-year infrastructure cost plan as given in Table 2.1.

Table 2.1: Estimated cost of required infrastructure investment in 10 years

10 Year Infrastructure Cost (R billion) as at Jan 2017	New	Upgrade	Rehab	Total
Internal	39	22	58	119
Connector: potable	22	13	56	91
Local bulk	25	14	29	68
Regional bulk	47	13	41	101
Connector: non-potable	14	3	53	70
Water resources	145	26	84	255
Total: Water	**292**	**91**	**321**	**704**
Sanitation	89	42	64	195
Total: Water Sector	**381**	**133**	**385**	**899**

Source: DWS (2017a:9)

Although the government's investment efforts to bring and maintain stability in the water sector, closing the WSI gap has become a mammoth task. The WSI gap links to the existing funding gap of about R333 billion (DWS, 2017b) (See Figure 2.5).

Figure 2. 5: Funding Gap over the next 10 years

Source: DWS (2017b: 29)

The current investment demand for the provision of WASH is estimated to be R899 billion over ten years, and the figure is above the allocated funds which are estimated to be R566 billion. Hence, it implies that an amount of R333 billion is a shortfall that the government must invest, given the current revenue-generating-capacity of the economy. However, the funding gap negatively affects the functionality of SWI and WSI management, resulting in WSDCs in the cities. Similarly, further evidence suggests that metropolitan municipalities' face a similar challenge of a funding shortfall, which is estimated to be between 10% and 18% of the capital expenditure needs (SACN, 2018). Therefore, a new approach to ensure municipalities generate adequate funds to finance the development and sustainable water management may be a sustainable solution to the prevailing WSDCs in cities.

In response to underinvestment challenges, the South African government through the DWS has put in place the National Water Investment Framework (NWIF) which allows three major cost components (investment, operating, and maintenance cost) to be quantified and bring the cost of sustainable water supply in line with revenue-generating capacity of the economy and water resources (DWS, 2018). Despite the NWIF's endeavours towards stabilising the WSI situation, Infrastructure Dialogue (2015) confirms that inadequate funds for maintenance and operating expenses have contributed to reduced functionality and lifespan of SWI. Jacobs (2019) alludes to the same point when he reiterates that the growing demand for water services has created a mismatch between WSI demand and finance supply, thus, leaving the longstanding SWI underinvestment to continue growing unabated. Therefore, considering inadequate funding in SWI, diverse options of addressing sustainable water management challenges may continue to be explored to tackle WSDCs in cities.

However, the focus should be on investment in SWI within the water sector and other infrastructure components in other relevant sectors (roads, electricity generating, schools and clinics), which have a complementary effect on achieving an effective and efficient WSDS. Hence, it is fundamentally critical to consider infrastructure as a system theory that regards infrastructure as a product of interconnected elements that interact with other infrastructural elements (Ejigu, 2007). The system-of-system approach should be adopted in developing complementary sustainable infrastructural projects while bearing in mind that failure in one component would mean that all integrated water systems will be affected (Mansoor & Williams, 2018). For example, water supply is most likely to be affected by load shedding (electricity cuts), mostly since water pumps are powered by electricity. Considering the system-of-system approach and infrastructure as system theory, investments in SWI and institutions are not mutually exclusive from other infrastructure investments. Hence, apart from WSI needs as per NWIF, much consideration may be required in terms of the cost of developing other complementary projects to realise the objective of creating sustainable smart cities. To further understand why SWI underinvestement gap still exist, the next section looks at barriers impeding efforts towards achieving desired levels of water sector investments.

2.9 BARRIERS TO WATER SECTOR INVESTMENTS IN SOUTH AFRICA

Investments in public infrastructure are characterised by many inherent challenges emanating from the nature of the projects, such as externalities and a long-term time horizon (Bak, Bhattacharya, Edenhofer & Knopf, 2017). Notwithstanding the challenges associated with WSI, investing in SWI for the effective delivery of WASH services brings many benefits, including an increase in productive capacity, improved life expectancy, reducing climate change impacts, education, reducing pollution and reduction in water-related disease (UN-Water and WHO, 2014; Van den Berg, 2014). Despite acknowledging that WSI can bring many opportunities, South Africa is failing to deal with funding challenges (DWS, 2018). Failure to deal with an underinvestment gap may have triggered water security fears in the sector. Therefore, it is critical to acknowledge that the current funding gap may be responsible for causing ineffectiveness and inefficiencies to the functioning of existing WSDSs.

It is apparent that the government is financially incapacitated to fund the WSI; private investors must chip in to arrest the growing water crisis. According to EBRD (2019), private sector participation helps promote efficiency and quality of municipal services and infrastructure.

However, private investors regard the water sector as one of the most unstable investment markets because of some barriers such as cost recovery, capacity constraints, access to funding, and politically influenced procurement processes (GreenCape, 2019). McCallum's (2018) study focused on the private sector's investment impact on water purification infrastructure in South Africa. The study found that private investors give priority to financial returns over socio-environmental impacts. Regarding funding challenges within the water sector, the private sector's minimal participation may be contributing to IWM challenges that are spearheading WSDCs in cities.

Furthermore, private investors are discouraged from investing in the water sector due to low financial returns, political interference, lack of lifecycle support, shortage of investment-ready deals and no formulated socio-environmental impact objectives. Mercer (2018) identified specific barriers that influence private investors' involvement in the water sector. These include the high cost of development and transaction, the lack of an adequate funding model, faulty risk-adjusted returns, ineffective regulations and policies. Therefore, it is apparent that challenges that make the water sector less attractive to private investments exist, so it is critical to seek ways of overcoming barriers to achieve effective WSDSs.

As alluded earlier, SWI is controversially regarded as a public good (White, 2015); thus, attracting private investments in the water sectors remains a substantial task because of a lack of profit motive (European Commission, 2011; Sengupta, Mukherjee & Gupta, 2015). As a result, water is often habitually under-priced; hence, private investors feel discouraged to invest in businesses that give them low financial returns. On the same note, Annamraju, Calaguas and Gutierrez (2001) argue that the WASH sector finds it difficult to amass investments, particularly in developing countries where the government is often economically depressed, coupled with huge debts which they are unable to pay back in time. In attracting private investments, particularly in developing countries, Mukherjee and Chakraborty (2016) suggest that a series of reforms should be put in place, especially the legal framework which protects foreign investments. Therefore, bringing reforms in the water sector to lure private investors may bridge the SWI underinvestment gap.

One of the most significant aspects to be considered when investing in any business is the ability to recover the cost of goods or services provided, plus a premium. In the South African municipalities, so many issues have contributed to the problem related to cost recovery. Jacobs

(2019) suggests that factors such as failure to manage the growing demand for better service delivery, poor management of SWI, and indigents' issues have continued to derail cost recovery efforts by municipalities. In addition to the failure to recover water costs, water price does not reflect the full cost recovery associated with operations and maintenance expenses and capital expenditure (WWF-SA, 2014; DWS, 2017b). Moreover, water cost recovery is included in the narrative of non-revenue water (NREWA) lost through leakages. The Infrastructure Leakage Index of South Africa indicates the extent of water leakages through pipes suggests that metropolitan municipalities are rated at 5.5 points out ten (10). The extent of NREWA is another setback to municipalities when attempting to recover water costs, and the perpetuation of this problem will further cripple their financial viability (DWS, 2018). Given this scenario, private financiers remain reluctant to fully participate in the WSI market because the chances of recovering investment returns are minimal. Failure to recover costs implies that private investors will not accrue financial benefits (McCallum, 2018). Hence, there is a need to ensure that water institutions can improve their capacity to recover water costs and reduce NREWA to ensure funds needed for the purchase, maintenance, refurbishment, and renovation of the SWI are made available.

Besides other WSI barriers, the lack of management capacity in water institutions has led to many inefficiencies within the water values chain. Investors also assess the local municipal's ability to return the invested funds in addition to the premium. Considering the apparent signs of institutional incapacity in municipalities, no private investor would be interested in investing funds in the water sector. Furthermore, Jacobs (2019) highlights issues relating to poor FMPs: poor billing and failure to collect revenue from water users are the most pressing problems facing municipalities. Given this point, Makhari’s (2016) assessment on service delivery in three (3) South African cities, found that the government-induced financial dependency syndrome facing municipalities is mainly due to the failure to recover operating expenses from revenue generated, a high level of corruption, poor asset management and mismanagement of funds. Mokgopo (2017), on the other hand, singled out poor corporate governance practices in the form of nepotism, fraudulent activities and lack of skills as factors contributing to management incapacity have resulted in WSDCs. Still on this point, from the investors’ point of view, without addressing institutional incapacity problems, attracting adequate private investments remains a tremendous challenge in the public sector. Therefore, investing in strengthening water institutions would ensures that WSI is effectively managed so that private investors can develop confidence in governance institutions (Singh, 2014). Therefore, poor CGPs prevailing in municipalities continue to impede efforts towards addressing the WSI barrier to ensure improved functioning of SWI and sustainable water management. However, the water sector investment's environmental impediments continue to present challenges to SWI infrastructure. To further the discussion on this matter, the next chapter delineates litereature concerning the relationship SWI factors and IWM.

2.10 SWI FACTORS AND INVESTMENT IN WATER MANAGEMENT

Managing global transition in the next ten years is proving to be challenging as a resilient and sustainable infrastructure needs to be developed against the backdrop of various risks impeding infrastructure functionality (Bak *et al.,* 2017). Infrastructure is the backbone of the economy because of its ability to impact society, the economy, and the environment. Sustainable water management facilitates the provision of water services to water users, individuals, or organisations. However, in providing water services, SWI components are challenged with tasks related to SEGE practices which tend to influence the functionality of WSDS. Inefficiencies in the functioning of SWI are a setback to the proper management of WSI. Hence, the researcher suggests that without resolving SEGE practices that disturb the functioning of WSDS, IWM challenges and WSDCs will remain unresolved.

IWM is one of the most topical issues in water security and crisis discourses. According to Singh (2014), WSI refers to investment in infrastructure, which forms part of the water value chain and investment in institutions that govern the water value chain. To achieve effective WSDS, WSPs need to invest in infrastructure; hence, it is fundamental to investigate what affects IWM in cities. Caldecott (2018) argues that the availability of reliable, sustainable and resilient water infrastructure ensures that the adequacy of WSI and revenue flow is assured. It has become evident that without adequate IWM, the functioning and operation of SWI will be compromised as SEGE practices impose vulnerability on SWI, leading to increased demand in IWM (Ruiters & Matji, 2015). Based on this point, the relationship between sustainability factors and IWM is bi-directional, implying that both sets of variables have equal potential to influence each other. Despite a bi-directional relationship, the central assertion of this study is in line with the thinking of Alaerts (2019). Achieving a sustainable WSI environment does not only require increasing IWM but focusing on factors that determine the demand for IWM is also imperative to achieve stability in the water sector. Other central issues include policy and institutional quality improvements, encouraging water users to pay, and introducing proper economic incentives to attract investments. Hence, this study finds it fundamentally vital to debate how SEGE practices influence IWM for the effective delivery of water services in cities.

For this study, interrogating the relationship between SEGE practices and IWM is regarded as another dimension of confronting WSDCs. Understanding the link between SEGE practices and IWM, the discussion incorporates four main theories as alluded to earlier. Firstly, the public good theory (Samuelson, 1954) justifies why the government is involved in investing in SWI regarded as a public good (White, 2015). The theory of infrastructure-led development (Agénor, 2010) tends to regard increased infrastructure investment as a push factor to bring about economic development and growth. Hence, this theory explains why to undertake to invest rather than what determines investments. Ejigu (2007) contends that infrastructure as system theory, the provision of adequate water services is not only a function of existing SWI but emanates from interconnectedness between other infrastructure components. The relevance of the sustainability imperative as postulated by Radej (2007) encapsulates the need to balance economic, social and natural capital to achieve the most effective WSDS. Hence, incorporating the theories mentioned above in the discussion about examining the link between SEGE practices and IWM may provide fertile ground for developing ideas that can resolve WSDCs in cities.

2.10.1 Investment case for corporate governance practices

Corporate governance is a topical theme in sustainable development discourses. Governance issues in the water sector are apolitical, and they evolve around socio-economic misfortunes emanating from malfunctioning water utilities in developing countries (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2015). The latest South African King IV Report on Corporate Governance framework encouraged businesses to take cognisance of social, economic and environmental impacts within-host areas of operations (Institute of Directors in South Africa (IDSA), 2016). Good CGPs are composed of effective governance principles that assist an organisation in fulfilling legal and ethical requirements congruent with the agenda of sustainable development (Dzingai & Fakoya, 2017). According to the United Nation's (2018) report on water and sanitation, good corporate governance relates to many elements, but includes explicitly effectiveness in service delivery, openness, transparency, public participation, engagement, and responsiveness to dynamics in water demand management. Whereas in the context of South Africa's local government entities, CGPs links to compliance with MFMA (as prescribed by the Auditor General) which promotes good governance by enforcing public sector entities like local governments to comply with regulations and norms when dealing with financial management matters (Nelson, 2016). For this study, an effective corporate governance model in the local government ensures the effectiveness of sustainable water management and IWM to meet objectives relating to the provision of WASH services in cities.

This discussion centres on water institutions' (WSAs, water boards, catchment management areas, and the private sector) endeavours towards providing WASH services in cities. SWI is a public good and, as such, the government, through its proxies partakes in the governance of water issues. Rogers and Hal (2003) stress that the current water crisis directly connects to the current crisis of poor governance. However, poor CGPs continue to cause intolerable levels of dissatisfaction among water consumers (Morudu, 2017). Additionally, ineffective CGPs have further led to poor management of WSI, poor service delivery (PSD), poor asset management and poor FMPs (Vhonani, 2010; Ruiters & Matji, 2015; Maclean, 2015). Hence, improving corporate governance models may play a critical role in properly managing investsment in the water sector required to address WSDCs in cities further.

Additionally, governance issues relating to regulations and policies in the water sector require attention, as Mercer (2018) pointed out that ineffective regulations discourage investors from considering infrastructure investment in state-owned enterprises. Consistent with this, Bhattacharya, Meltzer, Oppenheim, Qureshi and Stern (2016) suggest that some of the countries that lack a coherent and trusted legal and institutional framework and under-developed institutional capacities, have continued to experience impediments in attracting private investments. Therefore, local governments are obligated to adopt good CGPs to ensure the effectiveness of sustainable water management and investment in cities where the water security issue remains a significant concern. Hence, adherence to good CGPs in local government is indispensable to achieving SDG 6.

However, it is crucial to understand how various CGPs influence IWM measured through investment in SWI and institutional capacity. In line with Cardoso (2015), CGPs dimensions include dimensions transparency and accountability, the composition of board structure, the relationship with stakeholders, legal, regulatory and ownership structure. For this study, it is essential to acknowledge that for these dimensions, SEGE practices and IWM are studied separately, with very few studies admitting to the link between the two (2). The empirical studies on the the local government regarding the link between CGPs and IWM are limited, scattered, and mixed (Jackowicz & Kowalewski, 2012; Gomes *et al.,* 2013; Ammann & Ehmann, 2017; Motubatse, Ngwakwe, & Sebola. 2017; Araujo & Tejedo-Romero, 2018; Rocha, Orellano & Bugarin, 2018). However, in the context of the private sector, the the empirical literature is abundant, and so the review of the extant literature incorporates all relevant literature from all sectors to gain a full understating of the current narrative. Whether it is the private or public sector, compliance with corporate governance principles is vital because it denotes both moral and legal obligations, particularly in managing public goods such as water, WSI and SWI (White, 2015). Corporate governance principles are a tool for guiding public office bearers to effectively manage public assets such as SWI and IWM. Hence, good CGPs are crucial to resolving WSDCs, and compliance with good CDPs is a realistic approach to transform urban places into sustainable cities equipped with highly advanced water technologies.

The majority of prior studies' results from having examined the link between governance and performance of organisations in terms of financial, investment and service delivery are mixed (that is, positive, negative and neutral) (Jackowicz & Kowalewski, 2012; Gomes *et al.*, 2013; Maphalla, 2015). Cardoso (2015) looked at the quality of corporate governance of two (2) Portuguese state-owned enterprises and their performance. The study's significant results indicate that the company with better quality corporate governance shows a better balance performance than the one with poor quality corporate governance (Cardoso, 2015). Achim *et al.* (2016) examined the link between corporate governance and business performance in companies listed on the Bucharest Stock Exchange. In considering the period 2001-2011, the study results are inconsistent. However, after considering only data for the year 2011 after the introduction of corporate governance principles, the relationship became positive, thereby confirming that good CGPs do have a positive impact on business performance. In contrast, Ammann and Ehmann (2017) evaluated the link between governance and investment performance and asset allocation in Switzerland. They found that corporate governance dimensions showed a definite nexus between investment performances, while the asset allocation decision shows no relationship with governance. These results further confirm that the relationship between these two (2) topics, corporate governance and IWM is elusive.

Corporate governance issues in both the public and private sectors consider gender equity in the management as a fundamental dimension. Admittedly, gender parity is still undeniably and perpetually the most topical issue in socio-political and socio-economic spectrums, and as such, it is yet to be seen whether the female representation in board management influences the performance of entities. Araujo and Tejedo-Romero (2018) investigated the effects of gender equality on municipal transparency in Spain. The study results acknowledged that, indeed, women's involvement in local governance is a progressive move as it promotes adherence to good CGPs, particularly about information coherence and openness, communication, and accountability. In support of previous study results, Brenya, Mensah, and Nyarko's (2015) study relating to examining women's participation in local governance in the Kumasi Metropolitan Assembly found that women's involvement in local government administration is necessary because of their effective management capability. Hence, women's representation in municipal management, particularly in public utilities is likely to improve IWM and SWI considering the results from earlier empirical studies.

Contrary to other studies, Ionascu *et al*. (2018) studied business cases for women on the boards in European emerging markets. The results confirm that gender diversity variables have no significant effects on firm performance. Inconsistent with the above results, Adnan, Sabli and Abdullah (2013) evaluated the connection between gender diversity in boards and firm performance in 26 government-linked companies and 26 non-government linked to companies registered on Bursa Malaysia. The results reveal that gender diversity fails to yield positive financial performance (FP) as the number of women on the boards is still too insignificant to cause any firm performance changes. In Kenya, Ng'etich (2015) examined the corporate governance and FP of water companies. The results unveil that all corporate governance proxies (chief executive officer duality, size of the board, number of the board meetings, board composition and size of the firm and gender diversity of board) show a positive relationship with FP. Therefore, there is a need to restructure management boards to accommodate more women as most developing countries experience hardships in fetching water from various sources. Hence, the presence of women on public entity boards is likely to influence the management of SWI and WSI.

Furthermore, Rocha *et al.* (2018) analysed the relationship between a mayor's private and public finance. They found that educated mayors tend to spend less on their private expenditure, and as a result, they channel more funds towards the public expenditure to improve the performance of public entities as this tends to convince the government to inject more funds in the form of conditional grants. Jackowicz and Kowalewski (2012), in their study, examined internal governance mechanisms and pension fund performance in Poland. When using a hand-collected data set, evidence suggests that the composition of the supervisory board and the knowledge and motivation of the board members, are essential factors in explaining pension fund performance. Other governance factors do not affect pension fund performance. On the same note, it is essential to acknowledge that governance and political issues cannot be discussed in isolation in the public sector, Boubakri, Cosset and Saffar (2012) examined the impact of political connections on companies' operating performance and financing decisions using 234 politically connected compinies both in developing and developed countries. They conclude that politically connected companies have easy access to credit and reap benefits in their performance. Through CGPs, Environmental Protection Agency EPA (2017) conceded that asset management as a decision-making tool helps water utility seek the best approaches to reduce cost, invest in water infrastructure, manage replacement costs, and reduce unexpected operations and maintenance costs.

In the South African context, the Overall Index for Corporate Governance shows that South Africa obtained 2.9 out of 4 scores in both 2014 and 2015 (Institute of Internal Auditors of South Africa (IIASA), 2015), and this is a worrying issue in the public sector. Maphalla (2015) found that poor governance issues such as financial management malpractices (FMPs) and corruption harm the FP in municipalities, resulting in poor service delivery (PSD). In another study that utilised the Tobit regression model, Monkam (2014) analysed the local municipality productive efficiency and its determinant in South Africa. The results reveal that financial autonomy and the quality of human capital in management and administration influence the productive efficiency of the municipalities. However, poor governance issues such as FMPs and corruption impair FP in municipalities leading to poor delivery of basic services (Maclean, 2015). Given this scenario, gaining access to adequate private investments has become an unaccomplished task. Poor CGPs prevailing in municipalities range from inadequate planning, lack of resource management and poor water demand management have continued to impact the level of investments in the water sector (Harding, 2017).

Dlalisa (2009) analysed strategies for enhancing good CGPs in the South African local municipalities. The study identified poor CGPs in the form of poor FMPs, ill-advised appointments and misguided patriotism. These poor CGPs determine the state/outcomes of audit reports in municipalities. Sibanda (2017) focused on financial management performance and related CGPs in Eastern Cape municipalities. The results reveal that governance issues concerning poor financial planning, lack of accountability, unethical practices and lack of effective internal controls continue to contribute to municipalities' failure to obtain clean audit reports. However, these corporate governance failures imply that for government institutions to obtain good audit reports, adherence to good CGPs which promote accountability, openness, public participation and transparency are critical for public-sector infrastructure management. Motubatse *et al*. (2017) examined the effect of governance on clean audits in the South African municipalities. The results from the panel data analysis involving 45 observations explicitly proved that governance in financial management and leadership has a significant relationship with clean audits obtained by municipalities at the end of the audit process. Therefore, it is difficult for municipalities to attract enough investments if they cannot manage their affairs. This would mean that demand for IWM will continue to increase for as long as poor CDPs are still perpetuated in municipalities.

The European Commission (2011) posits that good governance directly influences the prospects of acquiring water finance. Poorly governed WSAs facing financial insolvency challenges linked to a lack of clearly defined objectives that lack government support, thus find it difficult to raise finance for WSI. Maclean (2015) argues that poor governance issues such as poor FMPs and corruption harm FP in municipalities leading to PSD. In a study, by Patience (2015) regarding infrastructure management in Ekurhuleni Metropolitan Municipality, the results suggest that challenges relating to technical staff shortage, poor planning and budgeting, ineffective succession planning and the non-existence of infrastructure knowledge are significantly contributing to poor management of the infrastructure, and thus compromising efforts to achieve optimum performance of the infrastructure. Ruiters and Matji's (2015) study on water institutions and governance models for the funding, financing, and water infrastructure management in South Africa acknowledged that the current water institutions and governance challenges are contributory factors to existing WSDCs. The extant literature presents proof that various corporate governance features have a significant influence on the performance of the organisation measured through various forms of financial and investment metrics. Hence, understanding how various CGPs impact IWM is a way forward towards addressing WSDCs in cities.

2.10.2 Water Investment Case for Social practices

As the world is going through many changes, transitioning social challenges are becoming evident, including uneven urbanisation, gender inequality, youth unemployment, stakeholder participation, and affordability constraints (Van den Berg, 2014; EBRD, 2019). Changes taking place worldwide are having an impact on water security because water is linked to many social factors such as the provision of WASH services, health issues, vulnerability to diseases and education and urbanisation (De Carvalho, Carden & Armitage, 2009). Furthermore, water security links to housing and infrastructure deficiencies in the cities (Turok & Borel-Saladin, 2014), and as such, water availability remains an indispensable issue in realising the notion of developing sustainable cities. However, a set of social factors influences the WSPs' financial condition, which influences sustainable water management and IWM in the local government. These factors are employment rate, population density, the wealth of population, literacy level and population size to age (Kleynhans & Coetzee, 2019). Given the impacts of social practices on the WSDSs in cities, it is critical to interrogate further how social practices influence IWM and affect the effectiveness and efficiency of the WSDS in cities.

However, the field of study relating to the impacts of social factors (in population growth, unemployment, strikes, housing issues) on IWM has not received much direct research attention as the majority of the extant literature is fragmented. Many studies confirmed that various social factors either have had a direct/indirect impact IWM, which is sometimes denoted through FP (Mahabir, 2010; Asoka *et al.,* 2013; Mukherjee & Chakraborty, 2016; Salahuddin & Gow, 2016; Gomez *et al.*, 2019). Considering social costs incurred through the destruction of infrastructure, Morudu (2017) used the quantitative approach to explore the relationship between service delivery protests and the level of service delivered by local municipalities in South Africa. He found that the low level of services in housing, electricity, sewerage and sanitation, refuse collection, school and hospital have mainly accelerated service protests throughout the country and often result in violence and the destruction of public infrastructure. The frequency of service delivery protests has increased, with private property and public infrastructure facing a significant challenge of being destroyed and increased social costs (Alexander, Runciman, Ngwane, Moloto, Mokgele & van Staden, 2018). Ndebele and

Lavhelani (2017) evaluated the connection between local government and quality service delivery in a local municipality in Limpopo Province, and it was found that the frequency of service delivery protests in various municipalities further proves a lack of participation by the local people in decisions concerning the provision of basic services. To further confirm the importance of public participation in local governance issues, Rivenbark *et al.* (2019) examined the link between local government performance and public participation in Italy. The results using the ordinary least squares regression model suggests that there is a significant relationship between local government performance management and citizen participation in local government. However, as a way of managing stakeholder demands, local governments must open platforms for public participation to avoid service delivery protests which might end up compromising the quality of basic services. The study acknowledged that PSD protests mostly lead to the destruction of SWI; hence, the government need to allocate more funds to make provision for damaged infrastructure.

In other studies, social factors are connected to economic growth (Tripathi, 2017; Furuoka, 2013; Gnade, 2013; Thuku, Paul and Almadi, 2013). The reason for considering the role of economic growth is that various studies confirm that economic growth may lead to accelerated infrastructure investment and vice versa (Ansar *et al.*, 2016; Muritala & Ogunji, 2017); hence any changes to the economy affect the IWM. The existing literature gap created by a lack of closely related literature on these two (2) variables, social practices, and IWM further provides a motive for further interrogating this matter. Considering housing as a social factor, Glossop (2008) examined housing and economic development in London. The results show that suitable housing can attract and retain important skills in attracting investments in cities. In the case of population effects on economic growth, Furuoka (2013) employed a bounds test to analyse the long-term relationship between population growth and economic growth in Thailand. The results support the population-driven economic growth hypothesis by indicating a long-run positive relationship between population growth and economic growth. In Kenya, a similar study by Thuku *et al.* (2013) on population change and economic growth, the vector autoregression estimation technique results indicate that population growth and economic growth are positively correlated.

Similarly, Ogra and Onatu’s (2013) study looked at Gauteng metropolitan municipalities’ housing development projects focusing on urban fringe areas. However, the study pointed out that an increasingly urban population led to accommodation shortages, and so the establishment of informal settlements gradually became a significant challenge in delivering essential services. These scattered settlements mean that the municipalities require substantial funds to expand the SWIF to reach out to the residents. To add to this, residents of informal settlements are poor and cannot afford to pay for the basic services. Therefore, funding for water provision remains the burden of the government as urban sprawl takes place, and more funds are needed to fund the expansion of the SWIF.

Kleynhans and Coetzee (2019) assessed the financial condition of South African municipalities in KwaZulu-Natal. The assessment used data from 2009 to 2015, and the results revealed that the ratio of people of non-working age to the total population is one of the most significant factors affecting the municipalities' financial condition. In contrast, Gomez *et al.* (2019) found that an increase in a rural population in middle-high income areas creates substantial pressure for the government to improve the SWIF. Besides, without substantial investments, WSDSs remains constrained. Mahabir (2010) found negative results in a study that examined the impacts of high population density on South African municipalities' performance regarding the increase in basic services provision expenditure. Asoka *et al.* (2013) examined the impact of population on infrastructure and service provision. They found that the water infrastructure's capacity responsible for providing basic services has been negatively affected by the population growth as clean water inaccessibility has become a significant challenge. The mixed results regarding how the population is related to FP/IWM require further investigation as this will help the local authority find solutions to long-standing WSDCs in cities.

Similarly, financial distress which has a noticeable effect on IWM in the municipalities, can be related to many social issues. This further proves the bidirectional relationship between infrastructure development and population. Tripathi (2017), in India, avers that estimates from the regression model suggest that infrastructure investment seems not to have a significant influence on population growth (measured through size, density, city population's growth rate); instead, infrastructure contributed to economic growth in India, improved standards of living and promote business activities. Gnade’s (2013) study was on basic infrastructure delivery and its welfare impact on rural and urban municipalities in South Africa. The study's overall results found that basic infrastructure investment in both rural and urban municipalities had significant impacts on GDP per capita, human development, literacy, poverty, and household income.

Furthermore, Jones and Walker (2007) used a multiple regression model to investigate local municipalities' financial distress. According to the results, the most influential social-related determinants of financial distress are population size and composition of revenue generated. In the same vein, in an analysis involving socio-economic variables and local governance of finances, Zafra-Gómez, Antonio and Muñiz's (2010) ordinary least squares (OLS) results reveal that socio-economic aspects, including housing taxes and economic wellbeing of the residents, determine a local authority's potential to generate revenue. Hence, the population as a social factor remains a determinant factor in managing infrastructure investment and sustainable water management.

Regarding urbanisation and infrastructure services and basic services in the cities, numerous studies contended that unplanned urbanisation influences sustainable water management's operation and functionality in numerous ways. A study by Mukherjee and Chakraborty (2016) examined the link between urbanisation and the demand for water and sanitation services. The results established that the high rate of urbanisation and economic growth has led to an increased demand for WASH services. However, given the high population in Sub-Saharan Africa, Asia, the Caribbean and Latin America, empirical estimates predict that to achieve universal access to WASH by 2019, a significant stock of investment is required to acquire the new SWI. Borel-Saladin and Turok (2015) examine urbanisation in South Africa on a sustainable trajectory. The study focused on whether population growth in the cities has improved housing, public services or not. The study acknowledged that employment growth coincided with demographic trends resulting in poverty eradication, and improved urban infrastructure development, which resulted in better access to services. According to the literature evidencing mixed results, it has become clear that social factors are a game-changer to the current WSI. Therefore, to achieve effective WSDSs, there is a need to embrace a holistic approach to confronting social factors that impact IWM.

2.10.3 Water investment case for economic praactices

Water and economic issues are intertwined and cannot be discussed in isolation as pointed out in the literature (Bourne & Zulunga, 2016; Gurara *et al.,* 2017; IADB, 2018). The fact that water services cannot be delivered for free implies that economic factors play an essential role in influencing WSI. According to Allianz Global Investors (2013), water delivery and treatment come at a cost although theoretically it is regarded as a free commodity; hence, there are mixed reactions when considering water as a public or an economic good (White, 2015). Economic factors are critical in determining the effectiveness of the WSDSs and the management of WSI critical for developing SWI. Besides other factors, it is clear that water investment is a function of the economic factors such as water price linked to cost recovery (Ruiters & Matji, 2015), inadequate budgets (Beyers, 2016) and FP (Maclean, 2015; Jacobs, 2019). Similarly, in line with infrastructure-led development theory, OECD (2016) explains that investing in water security has a positive impact on economic growth, while improved economic growth can also facilitate opportunities for policy reform, strengthening institutions for water management, and financing investments in water-related technologies, infrastructure and information systems. Additionally, UN-Water and WHO (2014) and Value of Water Campaign (2017) suggest that by investing in water, many economic opportunities accrue, specifically in the areas of design engineering and construction of water infrastructure, with employment and ethical business environment creation being some of the benefits to businesses and members of the public at large. Given this scenario, economic factors play a critical role in sustainable water management, as local governments transform urban areas into sustainable cities with effective and efficient WSDSs.

In line with the public-good theory, water commodification is not congruent with the UN's resolution about water as a basic human need with no one denied its access (Osborn *et al.*, 2015). However, amongst the economic factors impending effective management of WSI is the economic value attached to water services that do not reflect its actual cost of provision (Madumo, 2015; Leigh, 2016; OECD, 2018). A wide gap between SWI investments needs and the supply of finance available has been attributed to many factors such as undervaluing water resources and under-pricing water services resulting in poor cost recovery and capital intensive SWI projects and periods of recouping invested funds (OECD, 2018). Municipalities' failure to charge water prices that reflect full water cost provision has negatively affected all the activities related to the maintenance and operations of SWI and the capacity for WSPs to meet the capital expenditure (WWF-SA, 2014; DWS, 2017b). Therefore, the government dealing with water issues, through its subsidiary, has a responsibility to ensure that sustainable water management is developed by providing adequate funding to close the existing investment gap.

According to Singh (2014), economic structure and resilience affect investment in SWI, and institutions involved in managing water security issues given the considerable underinvestment gap in the water sector. It has become critical to investigate the influence of various economic practices on IWM. From the literature synthesis, the researcher observed that the available related literature is elusive, with very few empirical studies examining the direct relationship between these two (2) factors, economic factors and IWM. However, various studies have revealed that financial/economic factors influence municipalities' service delivery performance as proxied by different metrics (Schoeman, 2011; Maclean, 2015; Başci & Başci, 2016; Mulenga, 2017; McCallum, 2018; Gomez *et al.*, 2019). These studies also acknowledged that various economic factors influence the delivery of services in the municipalities and to a certain extent, affect IWM. In a study done in Turkey, Başci and Başci (2016) examined the effect on the FP of 81 Turkish municipalities' investment decisions. According to the study's results, most financial ratios have a significant positive effect on drinking water investment except for financing ratios and tax to revenue ratios. Contrary to the same result, financing ratios and tax to revenue ratios positively affect the sewerage investment, while the same variables that showed a positive correlation with water investment, have shown a negative relationship with sewerage investment. Therefore, fostering FP improvement is an alternative approach to achieve effectiveness and efficiency in using SWI and ensuring the management of IWM.

In a study, Schoeman (2011) analysed the financial performance and sustainability of local government in South Africa. The study assessed the revenue collected from own sources, outstanding debt, ageing of debt and dependence on conditional grants. The results indicate that reliance on grants and poor performance on own-revenue collection continue to pose challenges to municipalities' sustainability. Similarly, most studies have shown that municipalities are struggling to handle revenue-related issues concerning revenue collection management. Makhari (2016) assessed water service delivery in three (3) cities: The City of Tshwane, the City of Cape Town and Ethekwini. Ironically, most of these WSAs remain dependent on the state government for subsidies as they are failing to recoup water costs. Mavhungu (2011) studied the non-payment for municipal services in the Vhembe district municipality. The study acknowledged that despite municipalities sending bills to residents, payments for services consumed are not forthcoming. Evidence suggests that residents are unwilling to honour their financial obligation due to ignorance, stubbornness and poverty. Maclean (2015), in turn, assessed the financial viability of selected municipalities in the Eastern Cape. His study contended that despite an existing coherent legislative framework to guide the financial activities, most municipalities lack adequate financial resources to effectively deliver basic services.

Furthermore, metropolitan municipalities are to a great extent, perceived to be financially viable though they lack the skills and the capacity to effectively use their resources for the betterment of quality service delivery as evidenced by underspending in water services provision. While smaller municipalities are failing to collect revenue from water consumers properly, their failure is a significant obstacle to implementing services delivery strategies. The study suggests that financial measures and ratios to determine the level, quality and success of municipal finances should be applied. Failure to recover cost related to services delivery jeopardises all the efforts intended to manage SWI and IWM for improved WSDSs.

Besides other determinants of IWM, the UN-Water and WHO’s (2014) GLAAS report on reducing non-revenue water highlights that a surge in NREWA continues to constrain the effective management of WSI and SWI. Numerous studies contend that an increase in NREWA has become a chronic financial challenge which has affected the performance of WSPs (Msomi, 2015; Yazid, Zaini, Chelliapan, Othman, Albati & Nasri. 2017; Murrar, Tamim & Samhan, 2017; Güngör-Demirci *et al.,* 2018). Güngör-Demirci *et al.* (2018) examined the determinants of NREWA for a water utility in California. A negative relationship exists between connection density, network length, and operating revenue per cubic meter of water sold according to a fixed-effect panel regression analysis. While several water leaks were identified as the primary determinant of NREWA, Yazid *et al.* (2017) examined economic and efficiency indicators in Malaysia's NREWA performance. They acknowledged that NREWA has regressive effects on the country's finances, water value chain, and the environment in general. Additionally, the study further identified that a high rate of NREWA is the result of corruption, lack of private investment, lack of adequate funding, lack of public participation, and political interference. Hence, the IWM issue remains an area of significant concern which requires the government to put in place measures to curb the problem of NREWA to avoid economic losses that harm the WSDSs in cities.

Murrar *et al.* (2017) evaluated the determinants of NREWA and financial viability for Palestinian WSPs. Factors such as staff productivity, energy cost, daily consumption, average price and WSPs’ size and structure significantly affect NREWA, with water production not having a significant impact. Similarly, estimates from the first regression model showed that variables such as services providers’ structure and size, energy cost, daily consumption, and staff productivity significantly affect NREWA. On the same note, financial viability was regressed over the same variables, and it has been established that all variable has a significant effect on financial viability except viability service providers' structure and size. Overall, the reduction of NREWA has had a positive effect on WSPs and has also led to an improvement in the quality of services under specific socioeconomic and institutional frameworks as in Palestine. In Zimbabwe, Maramba (2016) assessed NREWA for Norton Town using NREWA data from 2004 to 2015, the results of which are shocking. The average NREWA was 34% which surpassed the regional average of 20% to 25%. Inaccurate metering, the use of old and outdated meters, the absence of active leakage management was identified as the main contributing factors towards increased NREWA. Therefore, without addressing economic losses emanating from NREWA, achieving an effective WSDSs through proper SWI and IMW management remains a pipedream.

In South Africa, the average water loss is estimated to be 31.8%, with NREWA water sitting at 36. 8%, which presents an annual loss of over R7 billion when calculated based on the bulk water tariff (Mckenzie, 2014). Msomi (2015) studied NREWA management in Lidgetton, uMgungundlovu District Municipality in KwaZulu-Natal. The questionnaires survey, with data analyses using SPSS, reveals that the municipality does not take NREWA management seriously. Therefore, there is a need to ensure that municipalities focus on real economic losses associated with NREWA water to reduce it. Van den Berg (2014) focused on drivers of NREWA. The panel data analysis results from the fixed-effects model point that the level of NREWA has a direct relationship with many factors, including settlement patterns, population density, type of distribution network, the opportunity cost of water loss, and the environment in which the water utility operates. Therefore, the South African municipalities must find ways to reduce the level of NREWA to enhance the municipalities' revenue-generating capacity to ensure the achievement of SDG 6.

Extant literature further suggests that WSI has the potential to spur economic growth. In line with the theory of infrastructure-led development, infrastructure development can help to boost the economy and reduce inequalities. Gnade, Blaauw and Greyling (2016) examined the effects of basic and social infrastructure investments on economic growth and social development in South Africa. The results point out that investment in social and basic infrastructure spurs socio-economic development in both rural and urban areas, but it is more pronounced in the rural areas than in urban areas. Zhao, Tian, Lei, Boadu and Ren (2019) analysed the influence of local government debt on China's economic growth. Results reveal that when the scale of local government debt exceeds a certain threshold, economic growth is suppressed by the crowding-out of private investments and public expenditure reduction. Gomez *at al.* (2019)'s study on socio-economic factors affecting water access in rural areas of low and middle-income countries considered numerous factors in assessing factors determining water accessibility. Besides, governance factors, population, and female primary completion rate, Gross National Income (GNI) were a determinant of water access rates in rural zones. Hence, when the economy grows, water sectors' investment opportunities accrue attracting adequate funds to the sector to ensure cities are water problem-free.

2.10.4 Water investment case for environmental practices

The consequences of unsustainable environmental management practices (EMPs) on climate change have raised many questions regarding the resilience, longevity and sustainability of water infrastructure (Esterhuyse, 2012; Van den Berg, 2014). Although climate change is linked to natural events like solar output and volcano eruptions, human influence through poor land use, failure to conserve natural resources, and burning of fossil fuels have contributed a great deal to climate change (Harding, 2017). The impact of climate change is costly in terms of maintenance, repairs and lost connectivity; yet many of these impacts can be mitigated and avoided by pro-active adaptation measures (Schweikert *et al.*, 2014). In an exciting development, Chinowsky *et al.* (2015) explain that the AfDB suggested the need to make a provision of US$400 billion over the next decade to African countries to address developmental needs directly connected to climate change. Moreover, this suggestion provides further evidence that climate change-induced risk on SWI is an undeniable reality that has caused financial instability to WSI. Hence, massive IWM for building infrastructure that adapts to climate effects SWI has become critical to develop sustainable and resilient infrastructure (Caldecott, 2018).

The reality is that poor EMPs have led to the increased frequency of natural disasters that have severely affected infrastructure functioning at large (Nel & Denoon-Stevens, 2015). For example, high temperatures linked to climate change effects have continued to threaten food and water security worldwide (OECD, 2016). The effects of climate change have exposed critical infrastructure to new risks, especially infrastructure located in the coastal zones, which have become vulnerable to stormy weather and flooding. Koop and Van Leeuwen (2017) point out that as water utilities and water resources are threatened by climate change effects, the quality of life in cities becomes affected. It is fundamental to ensure that government builds an infrastructure that does not produce excessive carbon emissions or eliminates fossil fuels subsidies and increases carbon emission prices to reduce climate change impacts (Bak *et al.,* 2017). Hence, bad EMPs that trigger climate change are becoming a worrying issue as the functionality of SWI responsible for providing water services gets disrupted, resulting in increasing demand for IWM to restore stability to the WSDSs.

Given the impacts of poor EMPs on climate change, namely, effects on water security, the functioning of SWI, and destruction of water resources, the management of WSI has become a niche area that requires more attention than before. Mitchell, de Wit, Blignaut and Crookes (2014) suggested that in the absence of investment to cater for issues such as improvement in advanced infrastructural technology, the use of ecological engineering, improving sustainable water management, skills capacity development and improvement in assets management, local municipalities are likely to face severe service delivery protests accentuated by low economic growth. Therefore, to counter and mitigate the impacts of climate change, additional investments have become necessary to ensure that enough funding for the development of resilience and SWI is made available (Frone & Frone, 2014; OECD, 2016). The scale of demand for WSI is ever-increasing at an alarming rate due to climate change effects triggered by various EMPs. Although Bhattacharya, Romani, and Stern (2012) contend that quantifying the real investment needed for investing in climate-adaptive SWI seems complicated, the reality points to the fact that a relationship exists between EMPs and IWM. Therefore, it is vital to empirically examine the relationship between EMPs and IWM in the SAMMs to find sustainable solutions to WSDCs.

The EMPs, according to de Carvalho (2007) and Carden and Armitage (2013) are measured through many matrices, including frequency of droughts, precipitation, and wastewater management. However, Nyirenda, Ngwakwe and Ambe (2013) estimated EMPs through energy efficiency, water usage and carbon emission. About the studies examining the link between EMPs and IWM, there are only a few studies in this field, with most of them having mixed literature results (Chinowsky *et al.,* 2015; Schweikert *et al.*, 2014). Climate change effects have strong links to high temperatures, often resulting in heavy precipitation and flooding that directly or indirectly affect the functionality of SWI. Consequently, in justifying further interrogation into this matter, Chinowsky *et al.*, (2015) examine infrastructure and climate change by focusing on impacts and adaptations in Malawi, Mozambique, and Zambia. The results, based on a stressor-response approach to estimate the impacts of temperature, precipitation and floods on paved and unpaved road infrastructure, reveals that these three Africa countries are facing a potential US$596 million bill for maintaining and repairing heavily damaged roads caused by climate change effects such as high temperatures coupled with massive flooding. Schweikert *et al.* (2014) examined climate change and infrastructure impacts. They confirm that higher-income countries also face the challenge of climate change risks which result in substantial damage due to their very costly extensive road networks. In contrast, in low economies, the cost of damages is not as high because they have invested fewer infrastructure development funds than in the vibrant economies.

Similarly, the cost of maintaining damaged roads in developing countries is much higher than the funding needed for upgrading the existing paved roads. Based on infrastructure as a system theory (Ejigu, 2007), SWI does not work in silos, but interaction and interconnectedness among other infrastructure elements such as roads and electricity transmission units are vital in achieving efficient integrated water delivery systems. The construction of SWI mostly follows that pattern of the road network; hence any climate change-induced damage to roads is most likely to have the same impacts on SWI. Therefore, despite failure to accurately determine the anticipated costs relating to climate change effects, ignoring the anticipated effects of floods on the cost of investing in SWI will worsen the water security situation and impose high costs with the acquisition of the new SWI and maintenance of the existing infrastructure.

Furthermore, Juana *et al.* (2012) analysed the socio-economic impacts of climate change on Botswana water resources. Their results depict that climate change has become a determinant factor in the achievement of SDGs. Reduction in the level of precipitation driven by climate change has led to a significant decline in remuneration and households' welfare, subsequently leading to a decline in government revenue which is a source of funds for water infrastructure projects. The study by Grames, Prskawetz, Grass, Viglione and Blöschl (2016) regarding modelling the interaction between flooding events and economic growth acknowledged that rich economies invest in flood defence mechanisms while poor economies prefer to face flood damages as they occur. Rich economies can afford to invest in flood defence and therefore avoid severe infrastructure damage caused by floods. However, the poor economies will not grow when floods hit them because the consumption will decrease, and capital stock reduces as well. Harding (2017) assessed groundwater risk in the Laingsburg municipal area found in the Western Cape Province, South Africa. The results reveal that the groundwater is under severe strain because of climate change-induced risks, and this implies that SWI needs to be scaled up to develop climate-adaptive resources. Given the results from these studies, evidence suggests that climate change effects are a disaster to the functionality of SWI and a significant threat to IWM.

Additionally, studies focused on examining the relationship between EMPs and FP have produced mixed results (Nyirenda *et al.,* 2013; Maleka, Nyirenda & Fakoya, 2017; Ali *et al.,* 2019). For this study, the reasons for considering FP as a response variable in place of IWM are firstly, very few studies used IWM as a response variable. Secondly, an improvement in FP can attract investors, which would imply that current investment in assets will be affected. Thirdly, the higher the profit earned during a particular year, the higher the available funds for further investment in long term water assets. However, the above reasons imply that for any change to FP, funds invested in asset management tend to influence the relationship between environmental factors and FP either way. In a study by Nyirenda *et al.* (2013) the link between EMPs and firm performance in the South African mining companies was examined. The results from multiple regression statistics show that EMPs measured through energy efficiency, water usage and carbon have an insignificant influence on firm FP.

Another relevant study by Maleka *et al.* (2017) analysed the link between expenditure and waste reduction targets in South Africa. Based on the regression analysis model results, a positive and insignificant relationship exists between water-energy reduction targets and companies' profitability. On the same note, waste management expenditure was found to influence water reduction targets in JSE listed companies. For example, Ali et al. (2019) studied the impacts of environmental factors on waste, energy, resource management, and sustainable performance. The data from 173 Malaysian companies, were analysed using partial least squares and the results indicated that resource, energy and waste management have a positive influence on sustainable performance. Considering the bi-directional effect of the variables, He, Yin, Zhong and Ding (2017) evaluated the local government investment impacts on China's carbon emission reduction effect. The results from cointegration tests and panel data models indicated that local government investments significantly reduce carbon emission. Therefore, there is unambiguous evidence to prove that EMPs have an elusive influence on FP. Therefore, there is a need to guard against poor EMPs to ensure that a stable WSI environment free of WSDCs is achieved.

Some of the studies evaluated the relationship between EMPs and economic growth with mixed outcomes (Juana *et al.*, 2012; Brown, Meeks, Ghile & Hunu, 2013; Tomić, Komazec & Delić, 2014; Horta, Camanho & Dias, 2016a). Because economic growth opens up investment opportunities, this study regards it as the response variable. Tomić *et al.* (2014) examined the relationship between energy efficiency and economic efficiency, and their results reveal that improvement in energy efficiency is an excellent step towards sustainable development and therefore resulting in economic gains and eco-efficiency. Doungmanee (2016) examined the nexus between agricultural water use and the economic development level. The study reveals that the amount of water used for farming purposes tends to increase with a country's income. Horta *et al.* (2016a) conducted a study on the assessment of municipal services in the environmental efficiency of building construction. The results acknowledged that a new building construction's environmental efficiency has a significant connection with a high potential for performance improvement. Musouwir (2010) found that both national budgets on water and sanitation significantly impact the GDP per capita, which signals a positive economic growth. The environmental innovations are another approach to reducing the negative impacts of pollution, global warming and depletion of natural resources. Naidoo, Pearce, Visser, Crafford, Maila and Harris’s (2016) research investigated barriers and enablers of effective implementation wastewater charge by South African municipalities. It was found that the lack of organisational resources has created incapacitation problems that negatively impacted wastewater management. The study further pointed out that the cost of treating wastewater cannot be recouped if the wastewater charge structure is maintained. As such, it has become apparent that the economic growth effects of EMPs provide impetus to the current IWM.

Furthermore, Yang, Shi, Xu and Feng (2019) empirically examined the relationship between reducing carbon emissions and economic performance in China. The results show that China's low Carbon Policy, particularly environmental policy, has a significant impact on promoting regional economic growth. In comparison, Horta *et al.* (2016) compared Portuguese municipalities' performance (for the Period 2003 to 2009) in terms of residential building resource consumption. The results reveal that municipal performance tends to improve with the environmental policy expenditure and scale size, and decline with buildings' age, population density and the proportion of buildings with private ownership. Brown *et al.* (2013) analysed the effects of climate hazards on national-level economic growth considering the precipitation index (proxies by floods, drought and temperature) as an explanatory variable. They found a negative influence on economic growth as measured through the Gross Domestic Product (GDP). Therefore, these empirical results further justify the claim that climate change effects do have a significant role to play in terms of demand for IWM. Hence, investments in climate-adaptive SWI need to be scaled up to achieve the highest degree of resilience for effective and efficient WSDS.

Despite various efforts, demand for adaptive and protective infrastructure continues to skyrocket with the development trend not accurately traced because of climate change (Bhattacharya *et al.*, 2016). Contingency plans for scaling up water infrastructure investment for adaptation are imperative to achieving effectiveness in the operation of WSDS (Caldecott, 2018). On this note, EMPs have a significant effect on IWM, resulting in, either neutral or positive or negative impacts on WSI. Hence, further interrogation into this matter is imperative to seek the real impacts of EMPs on IWM in the case of SAMMs.

The afore-discussed literature review substantiates the research objectives and hypotheses highlighted in the first chapter. Therefore, to gain deep insights into the relationship between SWI and IWM in the SAMMs, a conceptual framework shown in the next section (Figure 2.6) illustrates the interaction between the variables in line with research hypotheses.

2.11 CONCEPTUAL FRAMEWORK

This study is conceptualised under following four main sustainable development dimensions, which include social, environmental, governance and economic factors. Given the current WSDCs across the globe, deficiencies in SWI and the lack of IWM are the main obstacles to achieve Agenda 2063, Goals 1 and 7. As shown in Figure 2.6, the conceptual framework provides an insight into this research examination of the interaction between SEGE practices and IWM in SAMMs. Several studies have found that IWM is a function of SWI factors that can enhance or disturb the functionality of the SWI and subsequently result in an uncertain situation in the management of water investments (Maclean, 2015; Nelson, 2016; Morudu, 2017). The interaction between SWI factors and IWM is pivotal in addressing WSDCs as the focus of this study. The SWI factors represent independent variables measured through social, economic, governance and environmental practices.

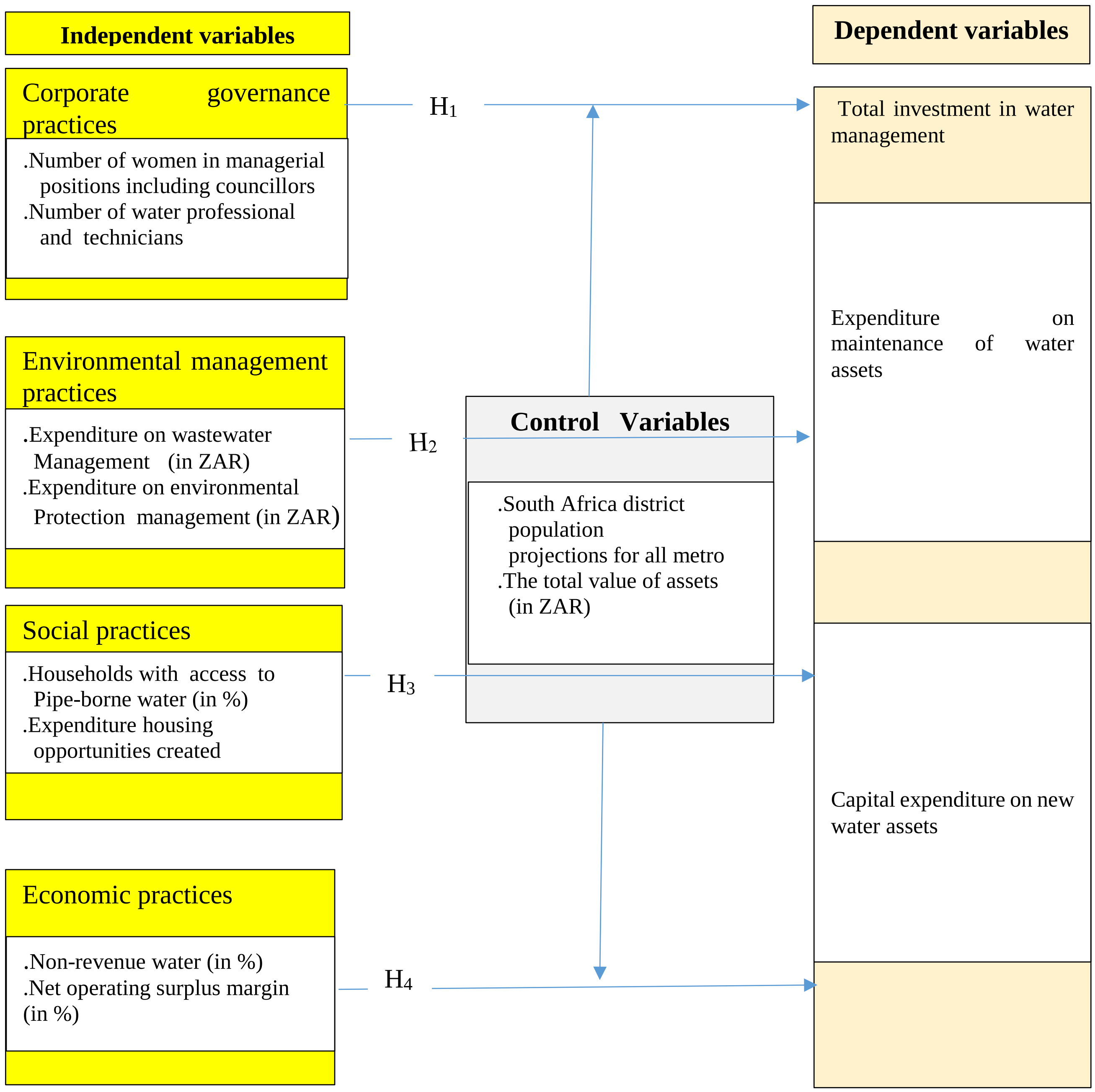

Figure 2.6: A Conceptual framework of interaction of SWI factors and IWM

Source: Own construct

In conclusion, IWM is a dependent variable represented by the expenditure on existing water infrastructure and capital expenditure on new water assets. The conceptual framework also includes the two control variables: population size and total assets value. In this regard, IWM is an essential factor in improving the service provision in cities. As such, addressing determinant factors that tend to create instabilities in the water sector environment is critical to improving water security. Therefore, the relationship between SWI factors and IWM is tested based on the conceptual framework proposed by the researcher. The conceptual framework proposed aligns with the research objectives, and it illustrates the interaction between variables according to the research hypotheses formulated in the first chapter.

2.12 SUMMARY OF THE CHAPTER

This chapter provides a brief discussion of the research context before explaining the concepts relating to SWI and Agenda 2063. Additionally, the theoretical frameworks applicable to analysing the relationship between SWI factors and IWM also formed part of the discussion. These include infrastructure-led development theory, theory of public good, infrastructure as a system theory and the sustainability imperative. In building SWI, all capital dimensions are inputs to the process and should have equal attention to guarantee positive results concerning achieving SDGs Goals (6 and 11) and Agenda 2063 (goal 1 & 7).

However, water provisioning progress is evident as the country has a sound and coherent regulatory framework that governs water management issues. The most critical pieces of legislation discussed in this chapter, include The CRSA (Act 108 of 1996), The NWA (Act 36 of 1998) and the WSA (Act 108 of 1997) Acts. Additionally, NWRS, NWIF, and The White paper on National Water Policy formed part of the discussion. Looking at the investment needs, South Africa requires substantive funding to ensure that WSDCs cease to exist. Furthermore, the study discussed barriers impeding the water sector in the South African context.

The most dominant issue discussed under the barrier to water sector investments includes a lack of management capacity in water institutions, corruption, water underpricing issues, access to funding, and politically influenced procurement processes and low financial returns. On the same note, WSPs are public institutions with the mandate to provide water through the political process. However, most politicians tend to abuse public offices by practising corruption, poor financial management, cadre deployment and nepotism. Therefore, to ensure that available adequate water sector funding is secured, the challenges relating to institutional incapacity requires urgent attention as the literature confirms that WSI challenges are associated with poor CGPs.

The subsequent section of this chapter provides a literature review of related studies on the link between SEGE practices and IWM. Water infrastructure is the backbone of the country's economy; hence, any threat to WSI is a threat to water security because it affects the functionality of SWI. The factors that drive IWM, including climate change, the state of the infrastructure, the economic situation, firm performance, population growth, rate of urbanisation, and technological environment. The literature review further delineates the discussion on the impact of each SEGE practices on IWM measured by the amount invested in SWI. The literature on the relationship between CGPs (public participation, corruption, openness, transparency, FMPs, skills capacity) and IWM also form part of the discussion. Moreover, various CGPs have a significant impact on IWM.

The literature went on to examine the relationship between EMPs and IWM. Many EMPs such as water and air pollution, burning of fossil fuels, poor land use have contributed to climate change effects which have become a threat to IWM. Thus, the assertion about the existing link between EMPs and IWM proved to be true according to the related literature review. In the context of social factors, issues like employment, income levels, water access rate, health issues, population growth, service delivery protests, and housing form part of the literature. Indeed, all these factors have a significant effect on IWM. Lastly, economic factors such as funding issues, water pricing, water cost recovery, financial losses induced by NRW, and debt management constituted the discussion on literature. Empirically, numerous studies show that there is a relationship between various economic factors and IWM. To sum up, findings from the literature review suggest that not all SEGE practices have a significant impact on IWM, thereby providing further justification for investigating this narrative under different contextual factors prevailing in the SAMMs. Lastly, the chapter presents a discussion on conceptual framework of the study.

The next chapter provides a detailed discussion of the overall research methodology and the steps involved, including the research design, the research approach, population selection, the sampling method, data collection, data analysis, and validity issues.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter two presented a discussion on the context of the study, followed by a clarification of the SWI. The chapter explained Agenda 2063, which is an African founded sustainable development road map. Additionally, the preceding chapter discussed the theoretical framework which underpins the study. To obtain a clear understanding of the governance of water service delivery in South Africa, legal and regulatory frameworks and water services strategies and plans were delineated in the preceding chapter. Furthermore, the chapter reviewed the previous literature regarding the relationship between SEGE practices and IWM.

The previous chapter focused on water sector investment (WSI), sources of finance and barriers to effective water investments management. In trying to understand various determinants of investment in water management (IWM), the chapter also focused on hypothesis development in the relationship between social, economic, governance and environmental (SEGE) practices and IWM. From the literature review, it was discovered that the relationship between the two (2) variables is elusive and inconclusive.

This chapter presents a detailed discussion of the overall research methodology to gain deep insights into this inconclusive narrative. According to Mackey and Gass (2015), research methodology is an overall strategy that commences with the problem identification, planning of the research process, setting the research parameters, choosing the research approach, data collection techniques and analysis approaches. Melnikovas (2018) describes research methodology as an integral part of the thesis, ensuring consistency between chosen tools, techniques and underlying philosophy. The choice of research methodology is strongly influenced by the research questions and investigation area (Creswell, 2009). Therefore, careful consideration was given to ensure that both research inquiry and methodology were aligned to achieve the same desired objectives.

This chapter deals with detailed methodologies that have been employed in addressing research objectives and testing research hypotheses. The chapter is presented in sub-sections. Section 3.2 gives an overview of the research process. Sections 3.3 and 3.4 discuss the methodological approach, and research strategies, respectively, while Section 3.5 focuses on the population, sampling technique and unity of analysis. Section 3.6 discusses the data sources, the data collection method and purposive sampling. Section 3.7 explains the independent, dependent and control variables used in examining the relationship between SEGE practices and IWM in the SAMMs; while Section 3.8 discusses data analysis procedures, including descriptive statistics and correlation matrix. Section 3.9 discusses inferential analysis: regression analysis, and econometric models applied, measures of significance, and correlations and panel data analysis. Subsequently, Section 3.10 and 3.11 discuss diagnostic and specification tests and linear panel data regression models, respectively. Section 3.12 delineates on validity, reliability and objectivity aspects of the study. The last two Sections, 3.13 and 3.14, discuss ethical issues and summarise the chapter, respectively.

3.2 THE RESEARCH PROCESS

This section introduces the research process which describes elements within the research realm and how they relate to each other. Research is a systematic process of undertaking a planned investigation to understand complex issues and add new contributions to the existing body of knowledge (Arthur & Hancok, 2009). According to Saunders, Lewis, and Thornhill (2012), the research process is a generalised model of undertaking research that takes the form of an onion. The research onion is a tool that assists in developing research designs and organising research elements by adopting a step-by-step approach that replicates the process of removing the layers of an onion (Saunders, Lewis & Thornhill, 2016). Raithatha (2017) stresses that the research onion describes all the main stages (in the form of the layers of an onion) in completing the research process to produce valid and reliable research results. Each layer of the research onion represents various research elements, with the outer layer denoting the philosophical approach and subsequently followed by the research approach, research strategies, time horizon, and finally, techniques and procedures for data collection and analysis as shown in Figure 3.1.

Given the nature of the research inquiry with a strong link to the social sciences, Saunders *et al.* (2016) point out that the research onion is the best guiding tool in developing a theoretical framework for the studies related to the field of social sciences.

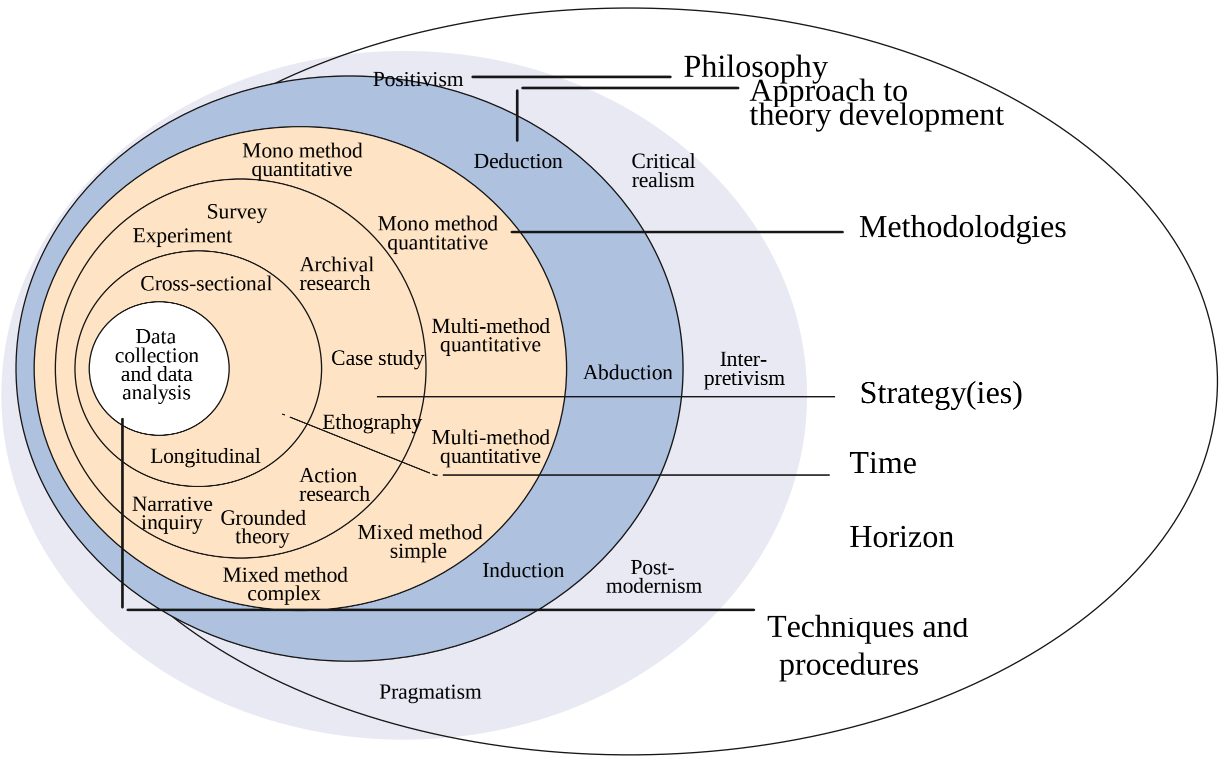

Figure 3. 1: The research onion

Sources: Saunders, Lewis and Thornhill (2016:124)

Similarly, Melnikovas (2018) expressed the same sentiments by pointing out that using the research onion in explaining the research process of the study has been widely recognised as a coherent strategy for developing the most appropriate research design. The research onion approach in developing the research process framework has been used extensively in earlier empirical studies (Mutezo, 2016). Therefore, this study developed a contextualised research onion showing specific research stages and elements for the study process (see Figure 3.2). In line with Saunders *et al.'s* (2012) view on applying the research onion model to come up with a convincing research process framework, the researcher clearly articulated all elements or stages of the research process as shown in Figure 3.2. The next section provides an in-depth discussion of various elements, or stages of the research process framework to examine the link between SWI factors and IWM in SAMMs.

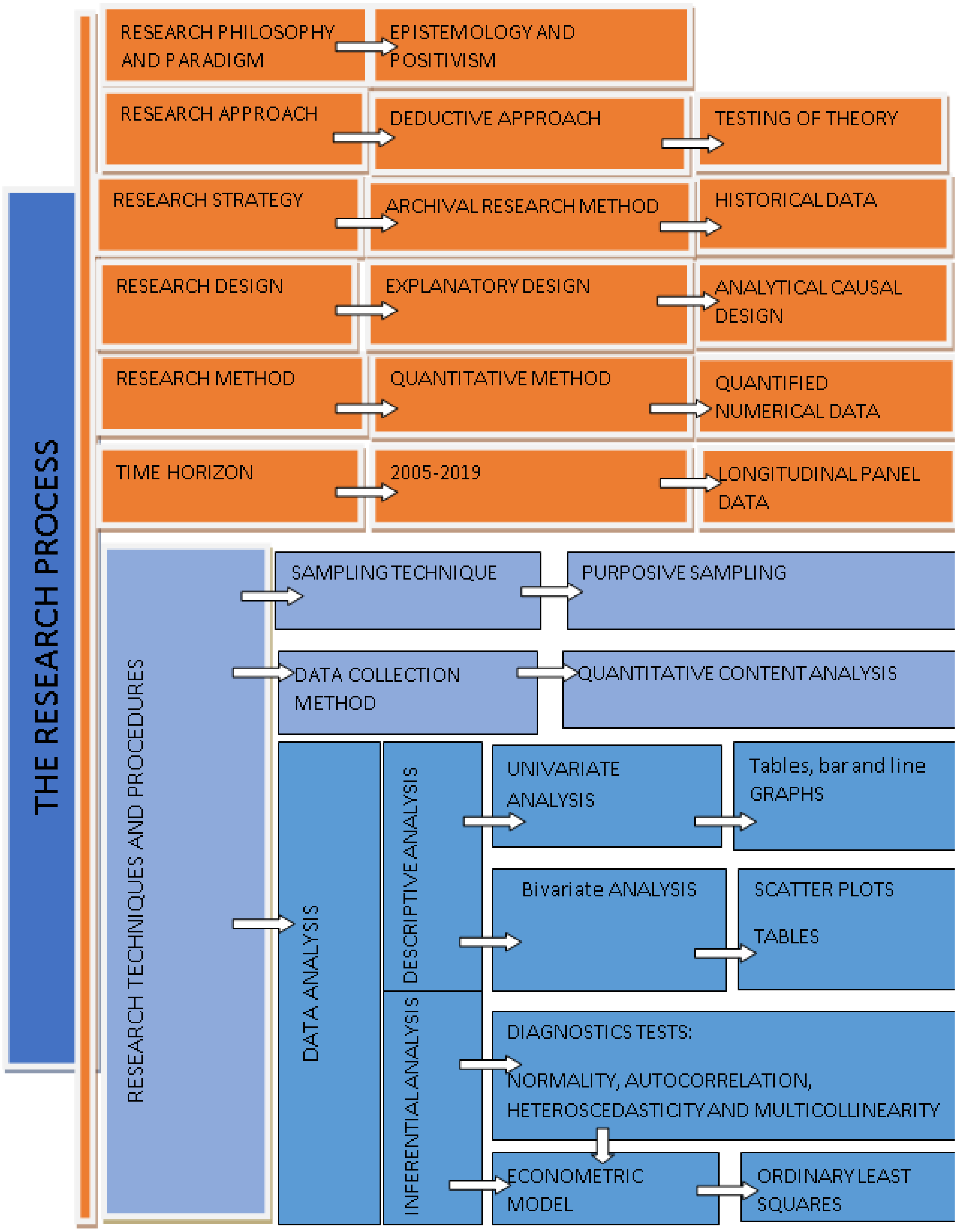

Figure 3. 2: The contextualised research onion.

Source: Researcher‘s construct

3.2.1 Research philosophy and Paradigm

The researcher was obliged to develop a sound research philosophy that provides a basis for undertaking the research. Saunders *et al.* (2016) define research philosophy as a set of beliefs and assumptions about knowledge development. Similarly, from the scientific point of view, research philosophy is a systematic representation of the researcher's thought process which allows the attainment of new knowledge through choosing the best research strategy, data collection and analysis techniques that address a well-formulated research problem (Žukauskas, Vveinhardt & Andriukaitienė, 2018). In formulating a research philosophy appropriate to address the research problem, a research paradigm that clearly sets human assumptions is imperative. The human assumptions include epistemology (acquisition of knowledge is not related to values and moral content), ontology (the reality is objective and perceived) and axiology (the role of values and ethics within the research process) (Saunders *et al.,* 2016).

Additionally, Saunders *et al.* (2009) point out that a well-thought-out and well-aligned research assumption is most likely to result in incredible research philosophy that will produce the best mix of all research elements/stages (research strategy, data collection and analysis techniques, and choice of methodology). Therefore, for this study, epistemology was adopted as a research paradigm because the research inquiry involved deducing knowledge from the existing scenario, which is independent of value and ethical content characterising the world.

The research process involves multidimensional philosophical approaches to understand reality. Therefore, in addition to human assumptions, the most common types of paradigms can be employed to access and draw the reality about the social world, including realism, interpretivism, and positivism (Žukauskas *et al.,* 2018). An interpretive research approach perceives reality as socially constructed and cannot be viewed independently (Fellows & Liu, 2008; Saunders *et al.,* 2016). The positivist research approach asserts that objectivism takes precedent over subjectivism as the scientists objectively understand the social world, and it is not associated with personal value and work (Melnikovas, 2018). The positivist assumption assumes that objective facts are a form of scientific evidence based on the researcher's influence on selecting quantitative research. Therefore, this study ignored the subjective nature of the social world and adopted the positivism approach, which perceives the world as independent from the people who live in it.

To further justify adopting the positivist research approach as a philosophical stance, Rao (2018) confirms that the domination of the positivist paradigm coupled with positivist epistemology that uses the model building, hypothesis testing, and deductive reasoning in the finance field. While Easterby-Smith *et al.* (2002) point out that the positivist philosophical approach is mostly associated with collecting numerical data, especially using experience and observation. Similarly, Saunders *et al.* (2009) state that the study that takes the dimension of a positivist stance is associated with using existing theories to develop hypotheses that might be confirmed or refuted resulting in further theory development. The fact that the analyses of objective and independent quantitative data are a basis for testing hypotheses, the positivist philosophical approach further influenced the researcher to select deductive reasoning as a methodological approach for this study. The next section provides a detailed discussion of the methodological approach.

3.3 METHODOLOGICAL APPROACH

The research philosophy mostly determines the best methodological approach applied when undertaking research (Saunders *et al.,* 2016). The second layer of the research onion represents a methodological approach that addresses issues to do with theory development as guided by deductive and inductive reasoning approaches (Saunders *et al.,* 2012). According to Melnikovas (2018), the deductive theory development approach is associated with deducing theories from already drawn hypotheses or formulated theories. Meanwhile, the inductive approach involves building or generating theories by exploring a phenomenon using research data collected. Ngulube *et al.* (2015) point out that the deductive approach involves identifying and formulating theories from research questions and hypotheses before collecting and analysing the data, which provides direction as to whether to reject or confirm the existing theories.

As depicted in Figure 3.3, concept and theory building is the difference between inductive and deductive approaches.

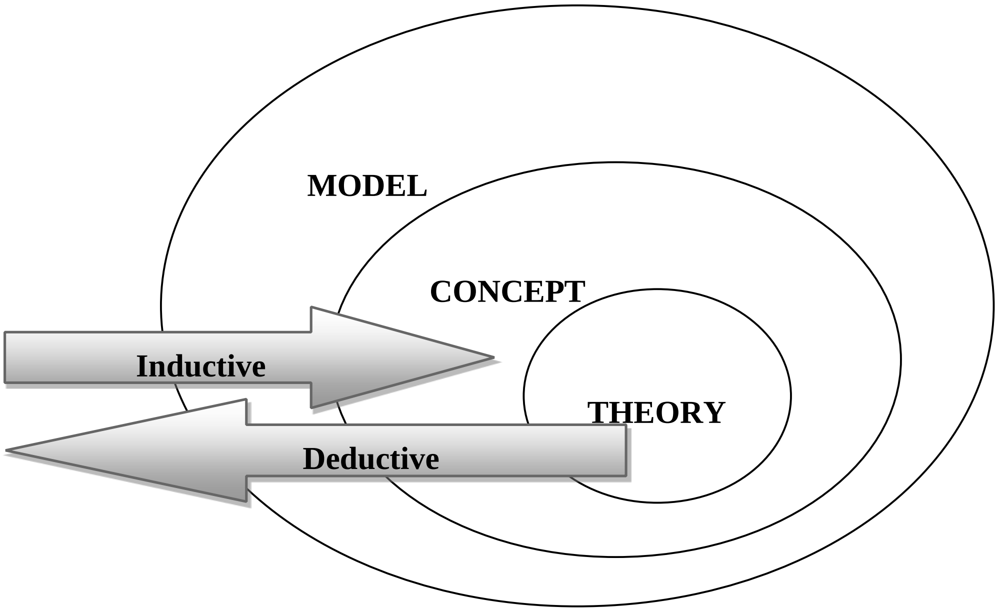

Figure 3. 3: Deductive and inductive approaches

Source: Ngulube, Mathipa and Gumbo (2015: 5).

The former begins with an observation to develop the theories, while the latter approach commences with formulating research questions and hypotheses based on existing theories, and expected observed data used to confirm or refute the existing theories. Saunders *et al.* (2009) point out that a deductive approach is mostly associated with explaining the causal relationships between variables and concepts.

This study adopted the explanatory research design because it sought to understand the ideas by establishing the relationship between variables. Since there is no definite conclusion concerning the link between SEGE practices and IWM, the deductive approach was applied to generate untested conclusions using a known premise that states that SEGE practices influence IWM. Therefore, formulated research hypotheses were tested and verified using panel data and econometric models. Earlier studies have adopted the deductive approach (Mukwarami, 2017; Thembo, 2018). The next section discusses the research design adopted by the study.

3.3.1 Research design

The research design is a theoretical construct within which research is managed (Mugenda & Mugenda, 2003). The research design is necessary for the smooth sailing of the research operation, and making sure that scarce resources such as money, effort and time are saved

(Kothari, 2004). According to Saunders *et al.* (2009), the most common research designs include descriptive, explanatory and exploratory research. Since a research design specifies the purpose of inquiry (Van Wyk, 2012), this study adopted an explanatory research design. Saunders *et al.* (2016) explain it as an approach to understanding ideas by establishing the causal relationship between variables. Additionally, to achieve consistency in the research process as already discussed in the preceding sections, the positivist philosophical approach mostly goes along with the deductive approach which tests the existing theories (Ngulube *et al.,* 2015). For this study, the hypotheses were developed based on general theories and thus gaining a deep understanding of how SEGE practices influence IWM in SAMMs; the only casual approach that was considered appropriate. Therefore, to examine the relationship between SEGE practices and IWM in SAMMs, the explanatory research design, involving an analytical causal research approach that establishes the causal effect of a set of predictor variables on response variables, was employed. The researcher considered the explanatory research design as appropriate because of its long roots in the history of empirical studies and its application in many studies (Gomes *et al.,* 2013; Başci & Başci, 2016). Therefore, the researcher believes that analytical research was the only alternative approach to successfully address the research inquiry even though only a few studies in this field used the approach. The next section discusses research methods.

3.3.2 Research method and justification for the choice

When conducting research, it is vital to choose the right research method compatible with the adopted research processes. To ensure consistency in choosing the right research method to address the research inquiry, the researcher considered the already chosen positivist epistemology stance, the deductive approach, and an explanatory research design to achieve compatibility. Various factors influence the research method's choice, including the research aim, the problem statement, and the type of data questions, as indicated in the extant literature (Melnikovas, 2018). According to Saunders *et al.* (2016), three main research choices are usually employed in addressing research objectives, namely quantitative, qualitative and mixed or mono methods. Qualitative and quantitative research approaches as methodological research dimensions differ entirely based on their ontological, epistemological and theoretical aspects (Eyisi, 2016). Saunders *et al.* (2009) describe the quantitative approach as any dimension of the research, which considers data collection methods and procedures that involve numerical data. Creswell's definition (2003) points out that the quantitative paradigm is unique because of its strength, including reliability and objectivity. To add on to that, it allows the results to be generalised to the entire population and testing theories (Melnikovas, 2018). Eyisi (2016) points out that the quantitative approach allows statistical data as a tool for time saving and resources. Table 3.1 provides more details about the quantitative approach's dimensions and their compatibility with other elements of the research process framework.

Table 3. 1: Compatibility of the quantitative approach with the research elements

Dimension	**Features: Applicability to the study**
Relationship between researcher and subject	**Distant**: There is no close association between the researcher and the metropolitan municipalities.
Researcher's stance in relation to subject	Outsider: The researcher is considered as an outsider since he neither worked for any municipalities in South Africa nor once had a close association with the metropolitan municipalities
Reality	**Objective and singular**: The researcher believes that social reality about the world is objective, and this applies to the influence of SEGE practices on IWM in the metropolitan municipalities, which can be objectively quantified.
Relationship between theory/concepts and research	**Confirmation of hypotheses**: Quantitative data were analysed statistically to confirm or refute the hypothesis

Source: Researcher's construct

Since the study's main objective was to examine the relationship between SWI factors and IWM in SAMMs, the compatibility of the quantitative approach with other research elements was not much of a problem. The researcher set the paradigm as positivism, and as such, quantitative research was the most appropriate method, especially when working with empirically observed and numerically measurable variables (Creswell, 2003). In this context, the researcher used numerical longitudinal data that share time-series and cross-sectional features to address the research inquiry. Additionally, the researcher's complete detachment and the unit of analysis implied that the researcher had nothing to do with how data was collected. Thus, any explanation, conclusion and interpretation drawn from the study reflect the researcher's control of the whole research process as alluded to in the literature (Eyisi, 2016). Besides, the quantitative research approach is one of the most common approaches applied by various empirical studies (Gomes *et al.*, 2013; Başci & Başci, 2016; Mukwarami, 2017; Tembo, 2018) that addressed the research inquiry into this field of study.

3.4 RESEARCH STRATEGY

The research strategy choice involved many considerations, including research questions, hypotheses, and scope of the study. A research strategy is a general approach that helps the researcher select the primary data collection methods to respond to the research questions (Melnikovas, 2018). This study's most common strategies include a case study, experiments, a survey, archival research action research, a narrative inquiry, grounded theory, and ethnography (Saunders *et al.*, 2016).

3.4.1 Archival action research

Archival research is one of the most popular research strategies used to address a research inquiry involving historical data stored in archives. According to Hageman (2008), the archival research method compels the researcher to use secondary sources and analyse data in archival records. Mohr and Ventresca (2002) define archival research methods as a range of activities applied to investigate specific past events about a particular organisation. In most cases, the researcher used historical documents, electronic databases, emails, and web pages to provide historical data.

However, the archival research method was not a common phenomenon in the accounting field until Ball and Brown (1968) introduced this approach, and researchers learnt to appreciate it. According to Hageman (2008), advantages associated with using the archival research strategy, includes high external validity, analysing trends over time, and most useful for the empirical measurement of relationships. Mohr and Ventresca (2002) also reiterate that archival research has many advantages, including minimising the subjects' biases because of the researcher's detachment from the collection of primary data. The archival research method was adopted as the study used secondary data mostly found in archival records (mostly in soft copies and web-based sources) concerning a sample of eight (8) SAMMs' annual records. Given the advantages of the archival research method, the researcher was satisfied with the approach's suitability, which led to its implementation.

Despite the usefulness of the archival research method, challenges also exist. The literature suggests that the archival research method lacks internal validity in terms of causal inferences as it is difficult to control for these and explain all the other alternative explanations that might affect the relationship. Similarly, the archival research method may be problematic when the model violates multivariate analysis assumption (Hageman, 2008). In circumventing the challenges, the study implemented various measures such as introducing control variables in the models, taking the variable's natural log to address heteroscedasticity, and creating lag variables to address autocorrelation as alluded to in the literature (Mukwarami, 2017; Tembo, 2018). Therefore, the researcher accepted the archival research method as the most appropriate approach to address the research inquiry that involves evaluating the relationship between SWI factors and IWM in the SAMMs.

3.4.2 Time horizon

The time horizon aspect in this research refers to the periods to be studied and chronological horizons of varying breadth (Melnikovas, 2018). The main objective of the study was to examine the relationship between SWI factors and IWM in the SAMMs. As such, the study utilised secondary historical sources through content analysis of annual and quarterly reports. Factors such as time, cost and availability of the research data were considered in determining the study period (from 2009 to 2019). However, one most important aspect that the researcher considered in deciding the base year was introducing the Municipal Finance Management Act (MFMA) 56 of 2003. The MFMA compels municipalities to prepare standardised annual performance reports and make submissions to the Auditor-general on an annual basis. In terms of a cross-sectional time frame, thirteen variables were collected from the annual reports of a sample unit composed of eight panels representing the eight SAMMs. The longitudinal approach was deemed appropriate to address all SEGE practices' research inquiry and their impacts on IWM in the SAMMs.

3.5 POPULATION

The population is a set of subjects under the study in which the researcher intends to study and generalise the results (Plümper & Neumayer, 2012). On the same note, McMillan and

Schumacher (2014) point out that the population encompasses all sets of items that share the same features that the researcher intends to understand and produce results for and about which the research intends to take a broad view of. This study's population comprised of all 278 municipalities in South Africa as per the municipal demarcation board. Common characteristics exist among the population subjects, particularly concerning SWI and water investment governance as guided by the Public Finance Management Act (Act 29 of 1999 (PFMA). For example, each of the population subjects (the municipalities) is responsible for providing water, which is common to all of them.

Given the features of the population subjects, water provision issues are centrally governed, and this implies that the central government through proxies is a role player in water provision. Although WSAs are allowed to draw up their strategic water resources management plans, they are must be drawn within the national water governance frameworks (Hollingworth *et al.*, 2011). This, however, implies that the strategies for resolving water crises are homogenous across the country, with a few disparities existing in specific municipalities based on contextual factors. Therefore, similar characteristics prevail across all population subjects in South Africa.

The most important characteristic existing among the population subjects is the adherence to the policies, regulations and legislation when preparing annual reports. All municipalities are obliged to prepare their annual integrated reports by following the (MFMA) (Act No. 56 of 2003), Circular 63 on annual reporting, Companies Act (Act No. 71 of 2008), (MSA) (Act No. 32 of 2000, Section 46(2), King IV on Corporate Governance, Circular 63, Treasury Regulations, and International Integrated Reporting Framework (IIRF). Additionally, all the annual reports should present information on governance structure and arrangements, auditors' reports, financial statements, financial and non-financial performance indicators against set targets as per the Integrated Development Plan (IDP). Given a coherent reporting framework, the presentation and preparation of annual reports in a similar format across all the municipalities means there is homogeneity in the presentation of annual statements, thus making comparisons across the municipalities to be undertaken efficiently.

3.5.1 Sampling: Purposive sampling

Sampling is one way of ensuring that the researcher selects manageable subjects from the population. Alvi (2016) defines sampling as any strategy or technique applied by the researcher to streamline the population into a manageable unit of study. When sampling, it is vital to ensure that the sample size does not lead to generalisation problems and the sample results provide a true reflection of the whole population (Neuman, 2011). Sampling is in two forms, namely probability and non-probability sampling. The former provides an opportunity for the subjects of the population to have equal chances of being selected.

In contrast, the latter is a technique that allows the researcher to exclusively select population subjects of choice without affording other subjects a chance to be selected (Plümper & Neumayer, 2012). This study considered factors such as time and cost of extracting data from various sources when choosing purposive sampling. Purposive sampling falls under the non-probability sampling technique. According to Tongco (2007), purposive sampling is a non-probability sampling technique that allows the researcher to intentionally select specific subjects from the sample because of the reasons stated above. The purposive sampling technique is associated with many advantages, including allowing the researcher to choose the research informants, being reliable and efficient, particularly when properly applied (Tongco, 2007).

The researcher intentionally selected eight metropolitan municipalities out of 278 municipalities, as shown in Table 3.2 . As stipulated in section 155(1) of the South African Constitution Act 108 of 1996, all SAMMs have exclusive and legislative authority in their areas, and hence the researcher also considered such factors in choosing the unity of analysis. Other considerations, such as time, cost, and data availability were considered. The next section provides a detailed discussion about considerations that were considered in trying to understand why only metropolitan municipalities were selected out of 278 municipalities.

3.5.2 Justification for considering metropolitan municipalities as a unity of analysis

In terms of the constitution, section 156(1) of South Africa, metropolitan municipalities have executive powers to administer all local government matters within their area. Further, all municipalities have a mandatory obligation to grow economies within their jurisdiction areas and provide and manage the infrastructure that provides essential services. There are 278 municipalities, comprising of 226 local, and 44 district and eight metropolitan municipalities. Through the provisions of the Constitution of South Africa, there are three categories of municipalities, namely: category A municipality (metropolitan municipalities) and when municipalities fall into categories B (local municipalities) or C (district municipalities). As directed by the Republic of South Africa's Constitution, the Municipal structure Act 1998 (Act 117 of 1998) provides criteria for determining the category under which various municipalities should fall. In category A, there are eight metropolitan municipalities, as indicated in Table 3.2.

The selection of metropolitan municipalities as the unit of analysis for the study was made after considering many factors. One of the factors considered is the population size of the metropolitan municipalities. Table 3.2 shows that SAMMs house at least 40% of the total population in South Africa, with the Gauteng province being home to the three biggest metros.

Table 3. 2: The eight major metropolitan cities in South Africa

Name of Metropolitan	Province	Households	Population Size
City of Johannesburg (CoJ)	Gauteng	1 853 371	4 949 347
City of Tshwane (CoT)	Gauteng	1 136 877	3 275 152
City of Ekurhuleni (CoE)	Gauteng	1 299 490	3 379 104
City of Cape Town (CoCT)	Western Cape	1 026 949	4 005 016
City of EThekwini (CoE)	KwaZulu-Natal	1 125 767	3 702 231
Nelson Mandela Bay (NMB)	Eastern Cape	368 520	1 263 051
Buffalo City	Eastern Cape	253 477	810 528
Mangaung Municipality	Free State	265 561	787 803

Source: Statistics South Africa (2016). /municipalities.co.za/demographics/ (2020)

However, the growing urban population in these SAMMs is one factor putting pressure on municipalities to redress urban development challenges. These development challenges include the high demand for basic services, management of limited land space, water insecurity, and growing the SWI underinvestment gap, remains a stumbling block towards building sustainable cities.

In line with the sustainable development goal (SDG) 11, cities must be sustainable, inclusive, safe and resilient (Osborn *et al*., 2015). Sustainable cities are expected to provide efficient basic services such as housing, water and waste collection. However, considering the unity of analysis, issues such as the shortage of housing and prevalence of WSDCs remain a cause of disagreement that influenced the researcher to select metropolitan municipalities. According to Stats SA (2016), big provinces such as Gauteng, Western Cape and KwaZulu-Natal have a housing backlog of approximately 1 842 079 due to the high influx of people looking for economic opportunities. Ogra and Onatu (2013) further point out that accommodation challenges are a phenomenon in Gauteng province's three major metropolitan municipalities, as shown by the increase in informal settlements coupled with urban sprawl. This has in turn, led to the development of housing units in the cities to accommodate the populace. Therefore, as housing units are being developed, there is a need to adjust IWM to accommodate new SWI projects aimed at reaching out to newly developed areas.

The population's growth, unplanned urbanisation, urban sprawl, and high demand for basic services such as water and sanitation present a significant challenge in the management of wastewater in the South African cities (Wall, 2018). Efficient and effective wastewater management is imperative to achieving socially, economically, and environmentally sustainable cities. However, metropolitan municipalities as the economic hubs of South Africa are not spared from the wastewater management challenges. The problems are made worse by the increasing number of informal settlements making it difficult to put in place sufficient infrastructure for sanitation service provision. On the same note, Naidoo *et al.* (2016) point out that the majority of the WSAs are struggling to achieve the right standard of water as the DWS's publication on the green drop for the years 2010 and 2011 shows that only 7.4% and 10% respectively of the WSAs achieved a green drop score exceeding 80%.

In line with the National Development Plan, the DWS handles water resources management and funding major water infrastructure development projects (Wegelin & Jacobs, 2013). Unfortunately, a severe infrastructure investment backlog has derailed progressive efforts to develop and manage water resources and WSDSs (Ruiters, 2011). Although progress has been made concerning water services provision in the SAMMs, it clear that a lot more must be done.

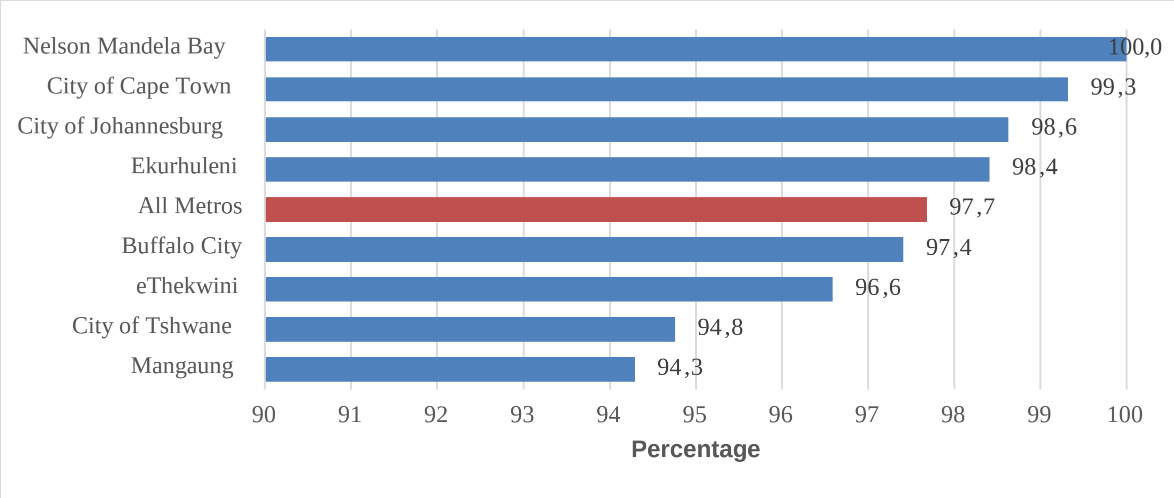

Figure 3. 4: Percentage of households with access to pipe-borne water in their dwellings and off-site

Source: Statistics South Africa (2017:38)

As shown in Figure 3.4, some residents in metropolitan municipalities do not have access to clean water, and for those with access to pipe-borne water can only access water far from their location (up to 500 meters away from their households) (Stats SA, 2017). According to the information displayed in Figure 3.4, only 97.7% of the metropolitan residents accessed pipe-borne water; thus, implying that 2.3% have no access to clean and safe drinking water. However, four of the SAMMs recorded water access rates below the average rate of 97.7%, with the City of Tshwane and Manguang having recorded the lowest access rates of 94.8 and 94.3, respectively.

Most of the water expenditure occurs in the metropolitan municipalities because of the high demand for water services driven by the factors above. For municipalities to address the water backlogs in their areas, more funding is needed, and this is against the backdrop of the existence of a long-standing SWI underinvestment gap. According to DWS (2017b), the funding gap is estimated to be R333 billion, and this requires the government to find new financing models to address the current infrastructure gap. In the context of SAMMs, the investment in SWI continues to be hampered by the lack of funding (Masindi & Duncker, 2016). Therefore, metropolitan municipalities' choice as a unit of analysis provided opportunities to understand how SWI factors are managed, particularly considering IWM challenges that are characterised by the SWI underinvestment gap.

Other reason for choosing metros as a sample population are that big municipalities in South Africa like metropolitan councils generate 83% of their income from their fiscal activities taking place within their spaces (RSADNT, 2018). These metropolitan municipalities' potential to generate their revenue further proves that they can play a critical role in addressing WSDCs within their areas using their own generated income. In the same vein, metropolitan municipalities can cross-subsidise between and within a different service and customers to avoid excessive reliance on government transfers. In addition to infrastructure grant funding, large municipalities can borrow from external sources to accelerate the rolling out of economic and social water infrastructure programmes (RSADNT, 2018).

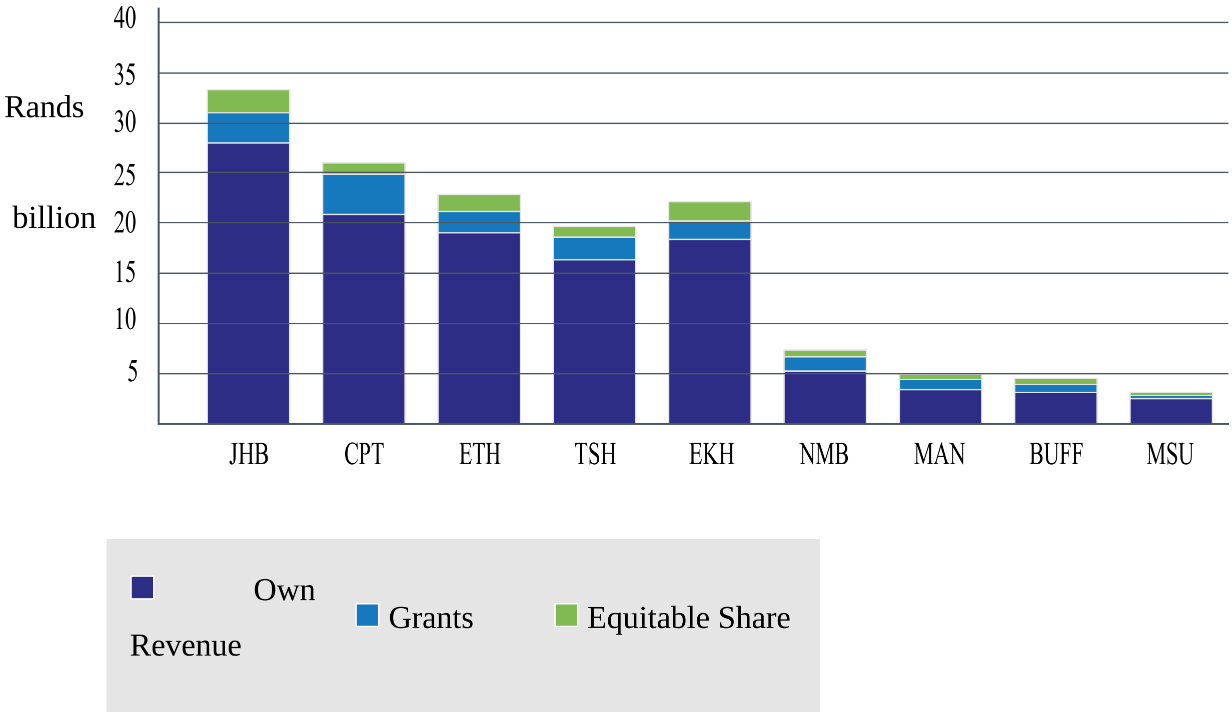

Figure 3. 5: Revenue by sources (2013/14)

Source: SACN (2016:252)

Regarding the information displayed in Figure 3.5, the five biggest municipalities in South Africa have managed to raise over 15 billion from their fiscal space for the year 2013/14. In addition to the ability to raise their revenue, most metropolitan municipalities received substantial grants from the government as alluded in the RSADNT's (2018) report on the state of local government’s finance and financial management for the years ending 2015/16, 2016/17 and 2017/18, and not even a single metropolitan shows a negative balance in their books. As metropolitan councils have been given executive power, with more authority being given to the mayor and executive committees, the automatic implication is that own generated surplus funds have no restrictions in terms of their use. Therefore, metropolitan councils have significant powers and rights to improve their capacities to address WSDCs through allocating additional funds towards sustainable water management.

In South Africa, there are 144 WSAs, and all eight metropolitan municipalities (DWS, 2018) have been given a constitutional mandate to provide a link between water boards and water users. Naidoo *et al.* (2016) stress that WSPs manage the infrastructure for development, maintenance, and water reticulation operation such as pump stations, pipeline and reservoirs. Apart from government transfers to aid in infrastructure development, municipalities ensure that the effective functioning of SWI is supported all the time. On the same note, metropolitan municipalities are known for spending a large amount of money on developing sustainable water management to improve their capacity to provide basic services, as shown in Table 3.3.

Table 3. 3: Capital expenditure (CAPEX) by infrastructure type (2010–2014)

METRO	JHB	CPT	ETH	TSH	EKH	NMB	MAN	BUFF
CAPEX (billions	2.90	1.15	4.58	0.42	0.78	1.17	0.56	0.13
% water of total CAPEX	12%	5%	19%	3%	7%	14%	14%	10%

Source: SACN (2016:259)

Despite considerable investments in CAPEX in the metro's water service delivery, challenges remain a phenomenon (DWS, 2018), thus, raising a critical question about other SWI factors contributing to the exacerbation of the water security challenges. Therefore, the researcher was prompted to interrogate this narrative further as a measure to seek sustainable solutions to the WSDCs crippling the progressive efforts towards developing sustainable cities.

In summary, the justification provided in this section influenced the researcher to purposively select SAMMs as a unit of analysis to address the research inquiry. The next section explains the data sources and outlines procedures for data collection.

3.6 DATA SOURCE

This empirical study examined the relationship between SWI factors and IWM in the SAMMs. In addressing the research objectives, the researcher considered multiple data sources to ensure reliability and validity as Johnson (2014) asserts that multiple data sources help boost confidence in the results, especially when two sources arrive at the same conclusion. Firstly, it is vital for the researcher to acknowledge that data is diverse; hence the researcher discovered that it could not be found in a single database. The most common data sources were found in the public domain, including newspapers, internet-based annual statements, and hardcopies collected from municipalities. The National Treasury's municipal finance data (http://municipaldata.treasury.gov.za) and the South Africa Local Government Association's (SALGA) municipal barometer web-based portal were the primary sources of the research data. Table 3.4 provides all the details from websites and names of the portals from which the data were sourced.

Table 3. 4: Data Sources for the study

	Soft and hard copies that provided data
1	Integrated development plan
2	Service delivery budget implementation plans
3	Water business plans
4	State of Local Government Finance and Financial Management report
5	Water services authority compliance assessment report
6	South Local Government Association (SALGA) Financial Reports
7	Cities Network Reports on Municipal Finances 10
8	Annual integrated reports
9	Municipal Budgets: Medium-term revenue and expenditure framework reports
10	Auditors' reports
11	Municipal Infrastructure (MIG) expenditure Reports

Source: Researcher's construct

Regarding the reliability of the data sources, municipalities undergo a compulsory audit process that reviews how they manage the finance, assets, infrastructure and basic service delivery

(Patience, 2015). Also, financial reports of municipalities are prepared following Generally Accepted Municipal Accounting Practices. Hence their reliability could not be questioned. The Municipal Finance Management Act, 56 of 2003, provides a reporting framework that compels all the municipalities and their subsidiaries to submit their annual performance reports to the Auditor General (AG) either before or on the 31st of August; except municipalities who are obliged to make submissions on or before the 30th September each year. The MFMA is fundamental in promoting reporting standardisation, making reports' data comparable across the board.

3.6.1 Secondary data collection instrument and procedure

The researcher collected secondary data for the period 2009-2019. The researcher used the Ms Excel spreadsheet as a temporary platform for recording data collected from various sources. All the issues to do with data management, including cleaning the data and dealing with missing data were addressed in the Ms Excel spreadsheet. Finally, data were imported into Eviews and Stata; the softwares used to analyse secondary data.

3.6.2 Secondary data analysis

The new technologies, which allow the creation of databases, have made it possible to collect, store, compile and retrieve vast amounts of data for research purposes (Johnston, 2017). Secondary data analysis uses existing data or previously collected data to respond to the research questions that were not part of the original research (Greenhoot & Dowsett, 2012; Cacciattolo, 2015). The secondary data analysis is quite relevant to various research designs, including exploratory, correlational and descriptive as it enables the researcher to draw meaningful conclusions from the large sample (Cacciattolo, 2015). Greenhoot and Dowsett (2012) stressed that the investigator's research questions determine the secondary data analysis's appropriateness. For this study, which followed the correlation research design, the nature of the research question related to how SWI factors influence the IWM in SAMMs provided an impetus for selecting secondary data analysis.

The use of secondary data analysis was helpful to the researcher in many ways. Greenhoot and Dowsett (2012) posit that if the existing secondary data fits into the research question, existing data is appropriate as the researcher is freed from committing much time, costs and effort to follow other steps in data management. Large numbers of constructs in the existing data set allowed the researcher to test the complex hypothesis through statistical data analysis techniques. Additionally, Johnston (2017) reiterates that the use of secondary data accelerates the pace of the research process since the data has already been collected, and at the same time allows more time for the researcher to engage in testing a new idea, theories and the framework of the research design. Therefore, the researcher adopted secondary data analysis as it fits well into the research inquiry, addressed through analysing longitudinal data (See Appendix B, Table 3.1-4).

Despite the many advantages associated with the use of secondary data, limitations do exist. The secondary data posed a few challenges as the researcher did not participate in collecting the original data and the processes involved in data preparation (Johnston, 2017). On the same note, it has become apparent that the researcher had no control over who sampled the data, what constructs were measured, or how they were measured (Cacciattolo, 2015). The issue of missing data is one of the aspects associated with using existing data (Greenhoot & Dowsett, 2012). Regarding the missing data, the researcher used multiple imputations as recommended by Greenhoot and Dowsett (2012), which involves using observed data to estimate missing value before the statistical analysis. Over and above, considering the research inquiry in question, a secondary data analysis approach was found to be the right approach to match the overall research design. Further information about the specific data collection technique used to collect data is discussed in the next section.

3.6.3 Documentary content analysis

The purpose of this study was to examine the relationship between numerically quantified variables representing SWI factors and IWM, and hence the documentary content analysis was employed to extract the data. According to Patience (2015), documentary content analysis is defined as analysing documents to extract data. Content analysis refers to all systematic and replicable data analysis (Neuendorf & Skalski, 2009). Rose, Spinks and Canhoto (2014) suggest that content analysis can be applied to diverse forms of written text such as letters or articles, pictures, videos, and films. Content analysis is flexible as it can be used for a wide range of text sources, and with the help of computer software, content analysis can cope with extensive data. The adoption of content analysis was found to have many advantages for the study, including saving time and cost, and convenience (Rose *et al.*, 2014). Therefore, through content analysis, annual reports belonging to eighty (8) SAMMs provided data for the study.

The relevant data were copied and pasted on an Excel spreadsheet customised to accommodate the time frame (2009-2019) and all independent, dependent and control variables. Its utilisation has influenced the adoption of content analysis in many empirical studies (Gomes *et al*., 2013; Mukwarami, Nyirenda & Fakoya, 2017).

3.7 EXPLANATION OF VARIABLES

The study examined the relationship between SWI factors and IWM in SAMMs. In line with Greenhoot and Dowsett's (2012) perspective on selecting the data variables congruent with the research objectives, the researcher made careful considerations in selecting the appropriate variables that address the research inquiry. Though the study took on a different dimension of an investigation by using a unique set of variables, the researcher ensured that the selected variables represented the correct measurement for SEGE practices and IWM. The fact that new variables were used, the researcher perceives an empirical approach employed by the study as a unique strategy of seeking answers to WSDCs in the South African cities.

3.7.1 Independent variables

The study aimed to examine the causal effect of SWI factors on IMW in the SAMMs. According to Saunders *et al*. (2009), independent variables have a significant power to cause an effect on the response variable. For the study, SWI factors are the independent variables as the literature confirms that IWM, directly and indirectly, responds to any changes in these factors (Ruiters & Matji, 2015). The researcher adopted a unique approach involving the categorization of SWI factors into four groups: social, environmental management, corporate governance, and economic practices (Madumo, 2015; WWF-SA, 2016). From each group, two proxies were selected, resulting in eight independent variables, in addition to two control variables that represented municipal size, as shown in Table 3. 5.

Table 3. 5: Independent variables classification and their proxies

N	Variable classification	Proxies for independent variables
1	Social	Percentage of households with access to pipe-borne water
		Number of housing opportunities created
2	Environmental	Expenditure on wastewater management (in ZAR)
		Expenditure on environmental protection management (in ZAR)
3	Governance	Number of women in managerial positions including councillors
		Number of water professionals and technicians
4	Economic	Non-revenue water (in percentage)
		Net operating surplus margin (in percentage)
5	Control variables	South Africa district population projections for all metro
		The total value of assets (in ZAR)

Researcher's own construct

$$* \text{ NRWA} = \frac{\text{number of kls of water purchased or purified} - \text{number of kls of water solds}}{\text{number of kls (kilolitres)of water purchased or purified}} \times 100$$

$$* \quad \text{Access to pipe} - \text{borne water} = \frac{\text{household accessing water with 200m from their yards}}{\text{total number of household}} \times 100$$

The researcher considered the independent variables shown in Table 3.5 as proper measures for SEGE practices which are regarded as inputs to the function of IWM. The next section deals with a detailed explanation of all independent variables.

5.7.2 Control variables

Control or confounding variables either relate to independent or dependent variables. Aduda, Chogii and Peterson (2013:124) state, "The essence of the control variables is to give recognition to the fact that several factors may influence the performance of a firm". For this study, two control variables representing the firm size were considered: population size and the total value of assets. In population size, no accurate annual figures are provided in the municipalities' annual statements as only 2011, and 2016 figures are available. Therefore, the study utilised district projections provided by Statistics South Africa to determine the population estimates. Population size plays a crucial role in influencing the cost-of-service delivery as established in various studies (Da Motta & Moreira, 2006; Kleynhans & Coetzee, 2019).

As the most popular measure of the firm size is the total value of assets (TVASS) owned by the individual entity, it was considered an essential dimension of the confounding variables. According to Aduda *et al.* (2013), total assets represent firm size as a control variable in most studies (Nyirenda *et al.*, 2013; Mukwarami, 2017). Concerning this study, the firm size represents the municipal size measured through total assets owned by an individual metropolitan municipality. In municipalities, the firm size determines the scale of operation, which is linked to expenditure and capability to generate revenue adequately. Hence, controlling for the effects of firm size on IWM help to account for potential spuriousness in the regression model.

3.7.3 Dependent variables

The dependent variable is the response variable that varies due to changes induced by the independent or predictor variable (Saunders *et al.*, 2009). For this study, which aimed to address WSDCs, through examining the relationship between SWI factors and IWM in SAMMs, considered three dependent variables measured through expenditure on maintenance of water assets (EMWAS), total investment in water management (TOIWM) and capital expenditure on new water assets (CENWI). According to the RSADNT (2019), water and sanitation services are financed through the Local government equitable shares (LGES) programme. Capital expenditure is financed through the basic service components of the municipal infrastructure grant (MIG). However, metropolitan councils contribute their significant revenue towards water and sanitation provision to complement the funds paid through LGES provisions. The reason for selecting IWM as a response variable was informed by its determining power to influence the water supply capacity and quality of water service delivery as indicated in the literature (Ruiters & Matji, 2015; UN-Water, 2018). Hence, the researcher used the unique approach of evaluating selected SWI factors on IWM in the SAMMs to address WSDCs.

Investment in water management refers to capital expenditure invested in new and existing infrastructure while operating expenditure is mainly bulk purchases (RSADNT, 2019). In understanding the investment role played by WSPs, the study categorised IWM into two, namely: investment in the acquisition of new water assets and investment in repairs and maintenance of existing water assets. For the study, infrastructure investment is represented by expenditure on the new water assets (CENWI). Although funding for infrastructure investment is a joint operation between all government spheres, metropolitan councils have a critical role to place because of their ability to generate substantial revenue within their fiscal space. Therefore, the researcher found it necessary to investigate the effect of selected SWI factors on IWM to address WSDCs.

According to RSADNT (2018), the necessary provision for funding repairs and maintenance is critical to providing efficient basic services. Expenditure on repairs and maintenance are activities relating to repairs, and preventative maintenance to avoid a tremendous loss of value through wear and tear was considered one of the critical variables in the study. In this regard, expenditure on repairs and maintenance included money spent on measures to reduce water losses, wastages, consumer demand management and inefficiencies within the water supply chain. However, funding for repairs and maintenance is mainly managed at the municipal level because municipalities are responsible for all the water distribution infrastructure within their areas of jurisdiction. It is essential to investigate the significant factors that drive the repairs and maintenance expenditure level in metropolitan municipalities to improve WSDCs in cities.

Lastly, capital expenditure on new water assets and expenditure on maintenance of water assets were added together to provide total TOIMW, which was regressed over SWI factors to address the primary research objective. Expenditure in water infrastructure as a measure of IWM was selected based on de Carvalho (2007) 's recommendation to assess the key performance measure in the delivery of water and sanitation services. Given the SWI underinvestment gap, many drivers influence the level of IWM, which influences the functionality of WSDSs in metropolitan municipalities. Therefore, the study interrogated SWI factors /IWM nexus to gain deep insights into what continues to derail the significant efforts channelled towards eliminating WSDCs.

3.8. DATA ANALYSIS

The purpose of the study was to examine the relationship between SWI factors and IWM in SAMMs, and as such, the secondary data analysis approach was employed in addressing the research inquiry. After all the data management processes were done as explained in the previous section, data were imported into Eviews and Stata, which helped generate descriptive and inferential statistics. However, similar panel data analysis procedures were followed as per earlier studies (Marozva, 2017; Thembo, 2018).

3.8.1 Descriptive analysis

The first phase of data analysis involved analysing data through descriptive statistics. Ali and Bhaskar (2016) defined descriptive analysis as a summarised description of the statistical data for a given sample in the study. The summary of descriptive statistics is composed of numerical and graphical methods of presenting data to allow a straightforward interpretation of the data (Tembo, 2018). The descriptive analysis only provided information that helped the researcher provide a general description of the research data. Descriptive statistics are in two forms, univariate and bivariate analysis.

3.8.1.1 Univariate analysis

The univariate analysis describes each variable, particularly by giving a summary description of central tendency measures such as mean, median and mode that indicate the central position within the data set (Dugard, Todman & Staines, 2010). On the same note, standard deviation, minimum and maximum shows the spread data and the ranges among the data variables within the data set. For the study, the statistics generated through a univariate analysis were presented in bar and line graphs showing the trend analysis of each variable and in tables giving summary statistics.

3.8.1.2 Bivariate analysis

The bivariate analysis provides information on the relationship's description involving two paired variables (Warner, 2012). The presentation of the results from bivariate analysis takes cross-tabulations, scatter graphs and quantitative measures of the dependent variable. For this study, scatter plots and line graphs were used to show the linear and non-linear relationships between the variables. The tables showed the quantitative measure of dependence represented by p-values and regression coefficients. In arriving at a more robust bivariate analysis result, the researcher computed Pearson's Correlation Coefficient. In the case of bivariate analysis, certain assumptions were observed:

- there is homoscedasticity of the data
- variables must be normally distributed
- Outliers must entirely be removed
- there is a linear relationship between variables
- The variable must be either interval or ratio measurement.

3.8.1.3 Correlational matrix

This study aimed to examine the relationship between SWI factors and IWM in SAMMs. In addressing the study's objectives, all thirteen variables were subjected to correlation tests to establish the strength and direction of the association between them. Consistent with other previous studies (Mutezo, 2015; Thembo, 2018), the study employed the Pearson correlation coefficient which generated correlation test results that the researcher interpreted based on the correlation matrix scale which ranges from -1.0 to 1 to interpret results. On the correlation matrix scale, close to 1 represent a strong correlation, while coefficients close to 0 point towards a neutral correlation. In terms of the association's direction, +/- signs represent positive and negative correlation, respectively. However, the Pearson Correlation test results were not conclusive in terms of determining multicollinearity as they only depict the paired correlations. Therefore, further tests on multicollinearity were done to establish the extent to which the variables are aggregately correlated.

3.9 INFERENTIAL STATISTICS

Inferential statistics allow the researcher to compare, test and predict data of a given sample of the population, and the researcher can draw conclusions which are generalised (Doucette, 2017). In this regard, consistent with empirical studies (Mutezo. 2015; Mukwarami, 2017; Tembo, 2018), the research hypothesis was either confirmed or refuted through undertaking various inferential analysis operations. To be specific, multivariate analysis was done to examine the relationships between SWI factors and IWM in SAMMs. In ensuring the econometric models' adequacy applied in testing research hypotheses, only diagnostic tests were done as per other earlier studies (Mukwarami, 2017; Tembo, 2018).

3.9.1 Regression analysis

Regression analysis is one common approach used for evaluating and analysing numerical data to establish the direction and significance of the relationship involving the response variable which is modelled as a function of the predictor variables (Mutezo, 2015). For this study, which examined the relationship between SWI factors and IWM in SAMMs, an appropriate econometric model was adopted to ensure the validity and reliability of the results. Saunders *et al.* (2009) describe the econometric model as the appropriate approach to testing the hypothesis to establish correlations. As discussed previously (see Section 3.7), the study used three dependent variables, eight independent variables, including two control variables to address the research objectives. Three multiple linear regression equations were performed since three dependent variables (expenditure on new water infrastructure, operating on water management and total expenditure on water management) were involved.

3.9.2 Econometric model specification

Three regression equations were performed to address the main objective in examining the relationship between SWI factors and IWM in SAMMs. The regression models were as follows:

$$EMWAS_{1=}\ \alpha_{10+\beta_{11}}\ WPTSE_1+\beta_{12}WOGOS_2+\beta_{13}EOEPM_3+\beta_4EOWWM_4+\beta_{15}HOUBC_5 +\beta_{16}PBWAR_6+\beta_{17}NOSMA_7+\beta_{18}NREWA_8+\beta_{19}POPSZ_9+\beta_{20}TVASS_0+\varepsilon_1 \quad (1)$$

$$CENWI_{1=}\ \alpha_{10+\beta_{11}}\ WPTSE_1+\beta_{12}WOGOS_2+\beta_{13}EOEPM_3+\beta_4EOWWM_4+\beta_{15}HOUBC_5 +\beta_{16}PBWAR_6+\beta_{17}NOSMA_7+\beta_{18}NREWA_8+\beta_{19}POPSZ_9+\beta_{20}TVASS_0+\varepsilon_1 \quad (2)$$

$$TOIWM_{1=}\ \alpha_{10+\beta_{11}}\ WPTSE_1+\beta_{12}WOGOS_2+\beta_{13}EOEPM_3+\beta_4EOWWM_4+\beta_{15}HOUBC_5 +\beta_{16}PBWAR_6+\beta_{17}NOSMA_7+\beta_{18}NREWA_8+\beta_{19}POPSZ_9+\beta_{20}TVASS_0+\varepsilon_1 \quad (3)$$

The main objective, in turn, split into four objectives as follows.

Objective 1: To determine the relationship between corporate governance practices and investment in water management (IWM) in South African metropolitan municipalities

$$EMWAS_{1=}\ \alpha_{10+\beta_{11}}\ WPTSE_1+\beta_{12}WOGOS_2++\beta_{19}POPSZ_9+\beta_{20}TVASS_0+\varepsilon_1 \quad (4)$$

$$CENWI_{1=}\ \alpha_{10+\beta_{11}}\ WPTSE_1+\beta_{12}WOGOS_2++\beta_{19}POPSZ_9+\beta_{20}TVASS_0+\varepsilon_1 \quad (5)$$

$$TOIWM_{1} = \alpha_{10} + \beta_{11}\,\mathrm{WPTSE}_1 + \beta_{12}\mathrm{WOGOS}_2 + + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (6)$$

Objective 2: To examine the relationship between environmental management practices and IWM in the South African metropolitan municipalities

$$EMWAS_{1} = \alpha_{10} + \beta_{13}\,EOEMP_3 + \beta_{14}EOWWM_4 + + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (7)$$

$$CENWI_{1} = \alpha_{10} + \beta_{13}\,EOEMP_3 + \beta_{14}EOWWM_4 + + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (8)$$

$$TOIWM_{1} = \alpha_{10} + \beta_{13}\,EOEMP_3 + \beta_{14}EOWWM_4 + + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (9)$$

Objective 3: To evaluate the relationship between social practices and IWM in the South African metropolitan municipalities

$$EMWAS_{1} = \alpha_{10} + \beta_{15}\,EHOCR_5 + \beta_{16}PBWAR_6 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (10)$$

$$CENWI_{1} = \alpha_{10} + \beta_{15}\,EHOCR_5 + \beta_{16}PBWAR_6 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (11)$$

$$TOIWM_{1} = \alpha_{10} + \beta_{15}\,EHOCR_5 + \beta_{16}PBWAR_6 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (12)$$

Objective 4: To evaluate the relationship between economic practices and IWM in the South African metropolitan municipalities

$$EMWAS_{1} = \alpha_{10} + \beta_{17}\,NOSMA_5 + \beta_{18}NREWA_8 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (13)$$

$$CENWI_{1} = \alpha_{10} + \beta_{17}\,NOSMA_5 + \beta_{18}NREWA_8 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (14)$$

$$TOIWM_{1} = \alpha_{10} + \beta_{17}\,NOSMA_5 + \beta_{18}NREWA_8 + \beta_{19}\mathrm{POPSZ}_9 + \beta_{20}\mathrm{TVASS}_0 + \varepsilon_1 \quad (15)$$

Where:

$CENWI$ = *Capital expenditure on new water assets*

$EMWAS$ = *Expenditure on the maintenance of water assets*

$TOIWM$ = *Total investment in water management*

$WPTSE$ = *Number of water professionals and technically skilled employees*

$WOGOS$ = *Number of women in management including female councillors*

$EOEPM$ = *Expenditure on environmental protection management*

$EOWWM$ = *Expenditure on wastewater management*

$EHOCR$ = *Expenditure on housing opportunities created*

$PBWAR$ = *Percentage of households with access to pipe-borne water*

$NOSMA$ = *Net operating surplus margin*

$NREWA$ = *Percentage of non-revenue water*

$POPSZ$ = *Population Size*

$TVASS$ = *Total value of assets*

β = *Beta representing coefficients explaining the partial elasticities of explanatory variables*

ε = *Error term*

α_{10} = *Constant for equation*

3.9.3 Measures of correlations and significance

The significance of the relationship between the independent and dependent variables was interpreted based on p-value which Saunders *et al.* (2009) describe as representative of statistical tests used to confirm the predictor variable's effect on the response variable. The significance level was set at 1%, 5% and 10%. To check the relationship's direction, regression coefficients were used to determine if the relationship is either positive or negative. R squared explains the goodness-of-fit statistic of the overall model and the proportion of variability in the response variable explained by the ordinary least square (OLS) and feasible generalised square (FGLS) models. The study's statistical approach is considered appropriate as a similar approach was employed in other studies and produced reliable results (Tembo, 2018; Tshipa, 2018). Therefore, this study followed an approach that interpreted the results on p-values and regression coefficient to maintain consistency.

3.9.4 Panel data analysis

Panel data is the pooling of observations characterised by cross-section and period features to make predictions (Baltagi, 2008). Pillai (2016) refers to panel data as a set of data containing observations with two dimensions: cross-sectional and time series. In simple terms, any form of data sharing two features, namely: time-series and cross-section, are called panel data (Brüderl, 2015; Chisasa, 2014). In this regard, the data's cross-section feature is represented by the extensive coverage of the study regarding the number of individual organisations being studied. For this study, eight SAMMs are considered separate entities that formed the study sample, and this implied that in total eight-time series datasets combined all together to form a single panel dataset. The time series feature of the data is represented by the fifteen years (2009-2019) considered the study's time horizon.

The researcher adopted panel data analysis because of certain advantages associated with the approach. In most cases, panel data analysis is influential when it is suspected that the response variable depends on predictor variables that are not observable but closely linked with the observed predictor variables (Torres-Reyna, 2007). Panel data has the advantage of improving the availability of more informative data which results in less collinearity among the variables and an increasing degree of freedom which cannot be addressed by either time series or cross-section data alone (Howie & Kleczyk, 2007; Baltagi, 2008). On a related note, panel data is known for dealing with complicated relationships that require inferential statistical analysis (Hurlin, 2010). Gujarati (2004) indicates that apart from covering complex relationships, panel data can uncover and measure effects that can be observed in neither pure cross-section nor real-time series.

Despite the advantages of panel data analysis, Baltagi (2008) posits that panel data is not a panacea for all the time series and cross-section studies as several weaknesses are associated with it. Panel data is associated with analytical problems such as heteroscedasticity (mostly found in cross-sectional data), autocorrelation (mostly found in time series data) and multicollinearity (mostly when closely related constructs are used) (Gujarati, 2004; Hoehn, Schuberth & Steiner, 2014). These problems make results from OLS models inappropriate to rely on (Certo & Semadeni, 2006). Therefore, to examine the relationship between SWI factors and IWM in the SAMMs, the study applied OLS amd FGSL panel data econometric models. To ensure that reliable and valid results were produced from OLS and FGSL approaches, all analytical problems were observed and addressed. The motive for diagnosing and addressing panel data challenges was to address the challenges relating to the panel data econometric model's adequacy and strengthen the validity and reliability of the statistical results. The next section provides a detailed discussion of the diagnostic tests undertaken in the study.

3.10 DIAGNOSTIC TESTS

As alluded earlier, panel data models may produce flawed results, particularly when the researcher overlooks the effects of threats caused by failure to observe regression assumptions on model results. Consistent with previous studies, the researcher subjected panel data to diagnostic tests to detect existing abnormalities and misspecifications which can influence estimators to be inconsistent and biased (Mukoki, 2015; Mukwarami *et al.*, 2017; Tembo, 2018). The diagnostic tests were conducted to ensure the econometric models' adequacy to produce valid and reliable results. The researcher performed tests to check for multicollinearity (Variance inflation factor); serial correlation (Breush and Pagan ML tests); heteroscedasticity (Breush and Pagan ML tests and White's general test) and cross-serial correlation (Pasaran CD test), stationarity (Fisher-ADF). Moreover, any violation of the regression model was taken seriously and as such, corrective actions were taken to address the problem.

3.10.1 Multicollinearity

Multicollinearity occurs when there is a strong correlation between the explanatory variables in question. Multicollinearity is likely to lead to model misspecifications which tend to create a bias to the results (Williams, Grajales & Kurkiewicz, 2013). If the degree of correlation is high enough, coefficient estimates become sensitive to any minor changes in the model. Besides, the precision of the coefficient of estimates is reduced resulting in the weakening of the statistical power of the regression model, and also casting some doubts on p-value when it comes to identifying statistically significant explanatory variables (García, López-Martín & Salmerón, 2015). For this study, the variance inflation factor (VIF) was used to calculate multicollinearity. García *et al*. (2015) suggest that a VIF above 10 poses a severe threat to the regression results. However, the researcher decided to increase the VIF limit to 10 to be consistent with previous studies that produced reliable results (Nyirenda *et al.*, 2013; Mukwarami, 2017).

3.10.2 Serial correlation

Serial correlation mostly occurs in time-series studies when the error term and different periods are correlated (Williams, 2015; Born & Breitung, 2016). Serially correlated error terms are most common in time-series data (Nakale, Coetsee, Arashi & Bekker, 2013). However, in panel data, serial correlation cannot be ignored as it results in inefficient estimates of the regression coefficient and biased standard errors (Drukker, 2003; Baltagi, 2008). The presence of autocorrelation in OLS based inferences tend to have test results with distorted sizes (Hahn, Hausman & Kuersteiner, 2004). Nakale *et al.* (2013) point out that when error terms in the model are serially correlated, OLS results become inefficient though they remain unbiased, thereby affecting the precision of parameter estimates (Williams, 2015). The Run-test for random order was done to check regression residuals for serial correlation. The run-test results are presented in two forms, namely; scatter graph and statistical significance of the random regression residual. The serial correlation in the scatter graph is detected by counting many runs above and below the threshold. Whereas, statistically, regression for serial correlation is denoted by a p-value less the 0.05. Therefore, if the data was found to have serial correlation, corrective actions were taken to address the serial correlation's problems to avoid distortion of the results.

3.10.3 Heteroscedasticity

Homoscedasticity is one of the regression assumptions which is unlikely to hold in the panel dataset. Violation of the homoscedasticity assumption in panel data regression analysis results in heterogeneity problems due to unequal variability of error terms. According to Adeboye and Agunbiade (2017), the problem of heterogeneity is associated with heteroscedasticity complexities that mostly exist in cross-section datasets. A heterogeneity problem in the dataset implies that heteroscedasticity is present, which is signalled by the errors that have a finite variance but not constant across different levels of the predictors (William *et al.*, 2013). However, the absence of homoscedasticity in the data set implies that heteroscedasticity exists, which can make pooled OLS completely biased and often results in imprecision (Agunbiade &

Adeboye, 2012; Hoehn *et al.*, 2014; Miller & Startz, 2018; Miller & Startz, 2019). Additionally, heteroscedasticity results in inconsistent estimates of the regression coefficient, which are inefficient, and in addition to that, errors of the coefficient are likely to be biased (Baltgati, 2008). In line with earlier studies, the researcher applied the Breusch-Pagan/Cook-Weisberg test check for heteroscedasticity robustness (Adeboye & Agunbiade, 2017). In both tests, the null hypothesis confirms the presence of the homoscedasticity, while an alternative hypothesis provides a signal for the presence of heteroscedasticity, which is undesirable.

3.10.4 Normality

Normality in panel data regression analysis assumes that the regressors and regressands are normally distributed (Williams *et al.*, 2013). Checking for normality in the error terms is critical in testing and estimation in panel data regression models. Similarly, the normality assumption is one of the crucial aspects of assuring the inference's procedures and specification tests' internal validity. Based on a methodological viewpoint, lack of Gaussianity often compromises the simple estimation and testing procedures (Alejo, Montes-Rojas, Galvao & Sosa-Escudero, 2015). Osborne and Waters (2002) posit that any violation of normality in panel data that uses pooled OLS as a regression estimation model leads to untrustworthy inferences, underestimating regression estimation coefficients, and distorting the relationship and significance tests. To ensure that normality was not violated, the most famous procedure, the Skewness/Kurtosis tests (sktest myresidual command in Stata) for detecting normality were applied to the panel dataset.

3.11 PANEL REGRESSION ESTIMATORS APPLIED

This section discusses the strength and weakness of ordinary least squares (OLS) and feasible generalised least square (FGLS) used to examine the relationship between SWI factors and IWM in SAMMs.

3.11.1 Ordinary least squares (OLS)

The OLS is one of the most popular panel regression estimators applied to the panel data set when examining relationships. According to Howie and Kleczyk (2007), data can be pooled across time series and cross-sections and perform the OLS regression model in the absence of the cross-sectional differences. However, failure to observe regression assumptions in the panel data before performing the OLS model, means that inconsistent estimators are likely to be produced resulting in compromising the results' reliability (Agunbiade & Adeboye, 2012; Adeboye & Agunbiade, 2017). It is highly impossible to have a panel dataset that is free of any threat linked to assumptions of regressions (Chisasa, 2014). It has been noted that heteroscedasticity and autocorrelation are common problems in cross-section data, and as such failure to address them usually leads to biased and inefficient OLS estimates (Agunbiade & Adeboye, 2012).

To ensure the models' adequacy as it was done in the previous studies (Mukoki, 2015; Mukwarami, 2017; Tembo, 2018), certain assumptions were made, mainly to achieve internal validity. Therefore, Tembo (2018) stresses that OLS results are unbiased when the following regression assumptions are met:

- Homoscedasticity implying equal variability of error terms
- Lack of multicollinearity implying there is a lack of strong correlation among predictor variables
- The error is assumed to be a random variable
- No serial correlation implying that error terms from different periods are not correlated

However, given the regression assumption, the researcher put in place corrective measures to address any violation of the regression assumptions to achieve internal validity and a significant level of reliance on the results.

3.11.2 Feasible Generalised Least squares (FGLS)

Generalised least square (GLS) is one of the panel data models which has long been in use in econometrics and is known for producing a more efficient estimator (Hahn *et al.*, 2004). Nakale *et al.* (2013) propose that generalised least squares are a generalised OLS technique that is the best linear unbiased estimator, particularly when the serial correlation coefficient is known. If the covariance matrix is unknown and needs to be estimated, the GLS estimator is not feasible, but the commonly used estimator is FGLS (Hahn *et al.,* 2004). Unlike in an FGSL model, serial correlation and heteroscedastic errors, OLS-based inferences, lead to tests with distorted results. The FGLS regression model can simultaneously address the problem of cross-sectional, heteroscedasticity and serial correlation (Mukwarami, 2017). The researcher considered FGSL in examining the relationship between SWI factors and IWM in SAMMs because of the model's strengths in circumventing violations to regression assumptions (Section 3.10). Despite the advantages, the motive of choosing FGLS to examine the connection between SWI factors and IWM in SAMMs was influenced by the extensive application in various empirical studies (Philippe & Durand, 2011; Miller & Startz, 2018). Lastly, for this study, the FGLS estimator was applied alongside OLS to ensure the results' robustness.

3.12 VALIDITY, RELIABILITY AND OBJECTIVITY

Validity and reliability of data collection technique, data sources, and data analysis techniques are part and parcel of the research process that influences the conclusion's meaningfulness to be drawn from the results (Babbie, 2013). The researcher was thorough in ascertaining each step of the research process to examine the relationship between SWI factors and IWM in the SAMMs.

3.12.1 Validity checks

Validity is a general term that is concerned with the question whether the research results reflect what they appear to be about (Saunders *et al.*, 2009). Similarly, validity reflects the extent to which research measures reflect what they should measure and approximate the results' truthfulness (Babbie, 2013). In this regard, a quantitative content analysis research approach was employed to examine the relationship between SWI factors and IWM in the SAMMs. Hence, validity was essential in providing checks and proper balances concerning suitability, adequacy, efficiency, and effectiveness of all research elements. Therefore, the researcher never compromised on validity and reliability issues to ensure that a meaningful conclusion was drawn from the study results.

For this study, the aim was to examine how the SWI factors influence IWM in these SAMMs, hence internal validity reflects the extent to which explanatory variables impact the response variables. Therefore, the researcher clearly defined and considered all forms of internal validity threats from data collected, tools used for collecting data, and data analysis techniques. Firstly, only validated data sources were considered, such as the Auditor General's annual reports, a municipality's integrated reports, and reports compiled by SALGA, SACN and Statistic South Africa. Secondly, multivariate data sources were accessed to validate the data to ensure that issues about data inconsistencies and conflictions received much-needed attention.

Additionally, in line with previous studies (Mukwarami, 2017; Tembo, 2018) concerning ascertaining internal validity during the data analysis process, regression assumptions were considered sensitive issues to be addressed before regression estimations results are relied on to conclude. Moreover, various diagnostic tests were conducted to establish whether assumptions of regression such as heteroscedasticity, autocorrelation, multicollinearity, and non-normality existed in the panel data. Therefore, the researcher implemented various strategies to address violations of the regression. Therefore, considering all the researcher's measures to assure internal validity, the study results are a reference point for evaluating the conclusion.

According to Saunders *et al.* (2009), external validity answers the questions about the extent to which the research results can be broad enough to be relied on when considering generalisation across the research spectrum. Further, according to Hageman (2008), the archival research method has the advantage of achieving high external validity. Thus, the study results drawn from the analysis of the relationship between SWI factors and IWM in SAMMs, reflect a broad spectrum of what is taking place in major urban municipalities. In short, the generalisation of the results is externally valid but mostly confined to urban municipalities that generate their own revenue, as rural municipalities have relied much more on government transfers.

3.12.2 Reliability

Maintaining reliability throughout the whole research process is a phenomenon in empirical studies involving the use of secondary data. Reliability reflects the extent to which the same results are produced when data analysis is repeated several times. All municipalities are compelled to provide annual reports audited by the Auditor-General; thus, an independent audit enhances the credibility and reliability of the data sources. Similarly, the AG assures the quality of financial and performance reporting in the public sectors; thus, the data's reliability cannot be doubted. Additionally, the study's quantitative content analysis is a reliable technique for collecting data as it was extensively used previously to produce unbiased results (Mukwarami, 2017; Tembo, 2018).

Furthermore, Eviews and Stata, which the researcher used as a data analysis tool to examine the relationship between WI factors and IWM in the SAMMs are well-known data analysis software used to analyse complex relationships. Eviews and Stata have been used in several studies and have produced reliable descriptive and inferential statistical results (Mukwarami, 2017; Tembo, 2018; Nyirenda *et al.,* 2013). Therefore, based on arguments that have been put forward, with certainty, the researcher confirms that the reliability aspect was observed throughout the whole research process, which ultimately led to reliable study results.

3.12.3 Objectivity

The most fundamental aspect of research is adhering to the objectivity principle during the data collection and analysis to avoid manipulation by the researcher (Saunders *et al.,* 2009). The underlying research philosophy is based on many factors, with the principle of objectivity regarded as a critical tool for ensuring the reliability of the results, particularly regarding conclusions (statistical generalisation) to studies that rely on quantitative research results (Žukauskas *et al.,* 2018). Eyisi (2016) suggests that researcher detachment is one of the strengths of the quantitative research approach as the researcher tends to have full control of alternative conclusions and explanations. Objectivity was observed when the researcher used archival secondary data collected by either independent or accredited persons/organisations. On a similar note, the National Treasury introduced (MFMA) (Act No. 56 of 2003) acts as an objective standard reporting framework that spells out all the procedures for reporting and submitting annual reports. Therefore, the researcher's complete detachment from procedures involved in collecting the original primary data provides a clear justification for ensuring the desired level of objectivity was reached and maintained throughout the study.

3.13 ETHICAL CONSIDERATIONS

Ethics and access to information have been the most important aspects throughout the whole process of undertaking this research. The most critical and sensitive aspects of the research that characterise good ethical conduct during the research process include confidentiality, anonymity, seeking permission and assuring security to the participants, and finding ways of dealing with the anticipated reactions of participants (Saunders *et al.,* 2009). Additionally, in compliance with the code of ethics in research, the researcher must obtain consent before starting the research process (Creswell, 2009). Seeking approval from the research participants is a way of ensuring that no intentional physical and emotional harm might arise out of all activities relating to the research project in question (Saunders *et al.,* 2009). Therefore, the researcher followed all the due processes involved in acquiring an approval letter from the university even though it was clear that the study's data could be easily accessed in the public domain and required no ethical clearance. Despite the Turfloop Research Ethics Committee's (TREC) declaration of the irrelevancy of ethical clearance, the researcher did not desist from complying with the research protocol prescribed in the University of Limpopo's research guidelines. More importantly, for research, academic confidentiality was maintained in line with research protocols, and the study results were presented to the thesis supervisor for further action.

3.14 SUMMARY

This chapter's focus was to discuss and justify the choice of the most appropriate research design and approach. Furthermore, the chapter described all the research process elements and how they relate with each other to address the research objective. In unpacking the whole research process, the researcher adopted a research onion approach founded by Saunders *et al.* (2012). The onion's outer layer is the research philosophy that the researcher considered to be a positivist research paradigm. The subsequent layer depicts a research approach related to the deductive reasoning approach that utilised quantitative secondary data (for the period 2009 to 2019). The secondary data was collected using content analysis from archival records concerning the SAMMs, mostly available on internet platforms. Since the study aimed to test the correlations between SWI factors and IWM, the explanatory research design was adopted. This incorporated the application of a causal analytical design to address the research inquiry. In terms of the study population, which was too large, the researcher employed purposive sampling to select a case of SAMMs.

Regarding the data analysis procedure, both descriptive and inferential analysis was employed, with the former describing the data in the form of graphs and tables. The latter involved the use of panel data regression models to examine the relationship between SWI factors and IWM. The panel data were subjected to many tests such as autocorrelation, heteroscedasticity, normality, and multicollinearity as a measure of archiving the desired level of internal validity. Similarly, the researcher applied OLS and FGSL as a panel regression estimators to determine the relationship between SWI factors and IWM after rigorous testing to ensure the models' adequacy.

The last section of this chapter discussed various validity and reliability tests undertaken to ensure that processes involving data collection techniques, data sources and data analysis techniques met the desired levels of validity and reliability. This enabled meaningful conclusions to be drawn from the research results. Objectivity was explained as the extent of the researcher's independence from the data's original collection process and sources from which data were extracted. Concerning ethical considerations, the chapter specified that no ethical clearance was required from the Turfloop Research Ethics Committee (TREC) because the data is mostly found in the public domain. The next chapter discusses and interprets the results of the study generated from Eviews and Stata.

CHAPTER FOUR: ANALYSIS, RESULTS AND DISCUSSION

4.1 INTRODUCTION

The preceding chapter discussed the research methodology followed by addressing the main research objective, which aimed to examine the relationship between SWI factors and IWM in SAMMs. This chapter provides a detailed analysis and discussion of the principal research results. The chapter is organised as follows: Section 4.2 provides an overview of how metros allocated their total IWM regarding capital expenditure on acquiring new water assets (CENWI) and expenditure on repairs or maintenance on existing water assets (EMWAS). Section 4.3 supplies information on the trend analysis for all the variables employed in the study. Section 4.4 presents information on descriptive statistics that included summary statistics, correlational matrix, and bivariate analysis. Section 4.5 discusses the statistical results from diagnostic tests conducted. Section 4.6 discusses the main results based on each of the four objectives. A framework for sustainable water management for improved investment in water infrastructure is provided in Section 4.7. Lastly, section 4.8 provides a summary of the whole chapter.

4.2 OVERVIEW OF MUNICIPAL SPENDING ON WATER INFRASTRUCTURE

Investment in water management (IWM) refers to the expenditure on new and existing assets. Figure 4.1 presents information on how each of the eight (8) municipalities allocated funds between CENWI and EMWAS (repairs and maintenance) during 2009 to 2019.

As shown in Figure 4.1, the assessment done during the years 2009 and 2010 suggests that less than forty percent of all metro's IWM was channelled towards repairs and maintenance. However, this implies that more funds (60%) were spent expanding the SWIF by acquiring new water assets across the metropolitan municipalities. The lack of balance in allocating funds between CENWI and EMWAS justifies why the backlog in repairs and maintenance caused by funding deficiencies still exists in metropolitan municipalities as alluded to in the literature (Infrastructure Dialogue, 2015). In the same vein, more spending on CEMWI between the years 2009 - 2011 is suggested to have had a direct link with preparations for the football world cup tournament and also with post-world cup events that stimulated economic growth (Du Plessis & Venter, 2010).

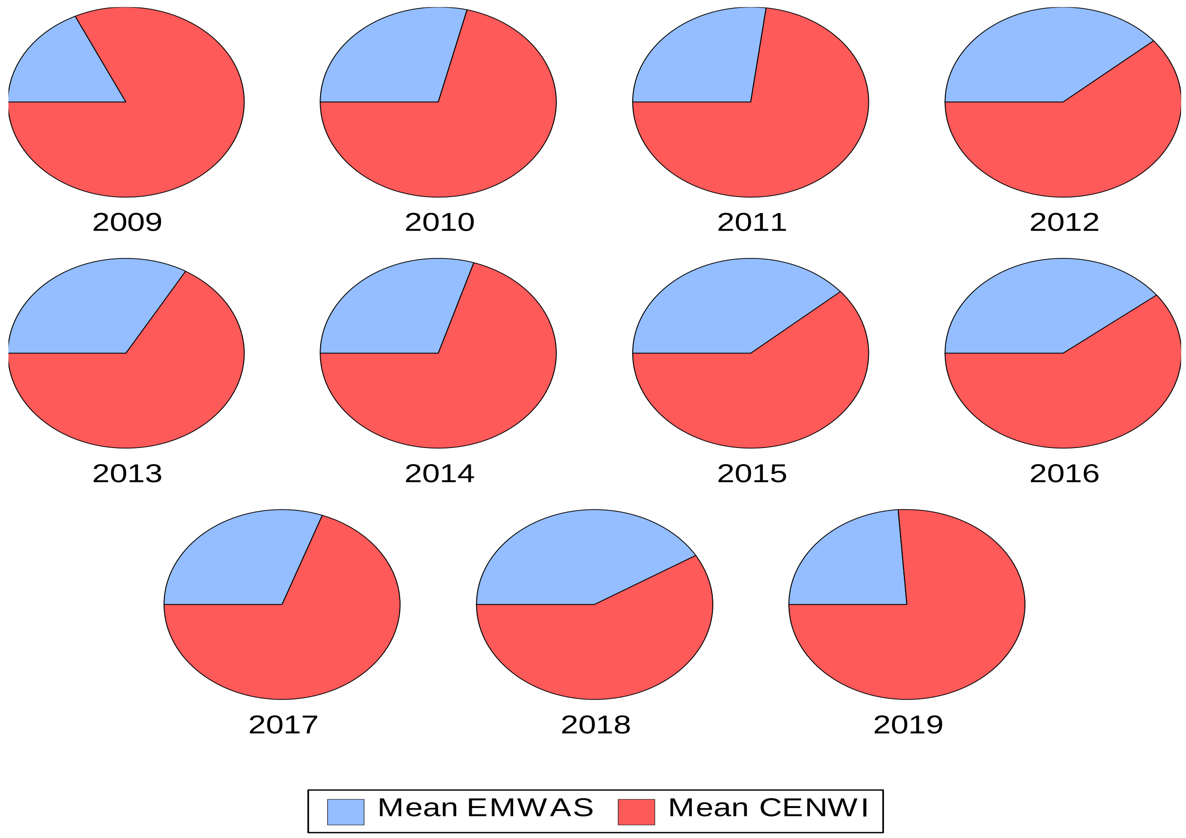

Figure 4. 1: Expenditure on new water assets versus existing water assets in SAMMs

Source: Researcher's construct

Generally, the post-2012 period was characterised by an increase in EMWAS, with CENWI slightly decreasing, and this further provides evidence of a paradigm shift in municipalities' water infrastructure sustenance policies as the government might have realised that the maintenance and repair backlog continued to grow due to underfunding as confirmed in the literature (Masindi & Duncker, 2016; Infrastructure Dialogue, 2017).

The ratio of CENWI to EWMAS for the years under review explains why WSDCs exist in metropolitan cities. Lack of adequate funding for repairs and maintenance is revealed against the backdrop of the existing strategic water infrastructure components which have almost reached the end of their life span and require frequent attention as they were developed during the pre-independence period (Infrastructure Dialogue, 2015). Additionally, poor asset management practices linked to inadequate funding have led to water infrastructure neglect which has resulted in water pipe leaks and burst pipes (SAICE, 2017). The level of unaccounted water is exceptionally high (Masindi & Duncker, 2016), and it has led to excessive economic losses that have continued to negatively impact the functionality of water services delivery systems (WSDSs). Therefore, the municipalities continue to experience IWM challenges as the cost of delivering water services cannot be fully recovered, and hence national government remains under pressure to continue increasing funding for the development of SWI projects.

4.3 UNIVARIATE ANALYSIS

This section presents information on each variable's description in the form of graphs showing trend analysis and descriptive information showing summary statistics.

4.3.1 Municipal trend analysis for expenditure on new and existing assets

The trend analysis for EMWAS and CENWI in SAMMs from 2009 to 2019 is based on the graphs shown in Figure 4.2. From 2009-2010, EMWAS remained constant, while there was a surge in repairs and maintenance costs during the same period. A slight decrease followed the post-2010 period in EMWAS which later started picking up in 2011 till it reached R200million in 2015.

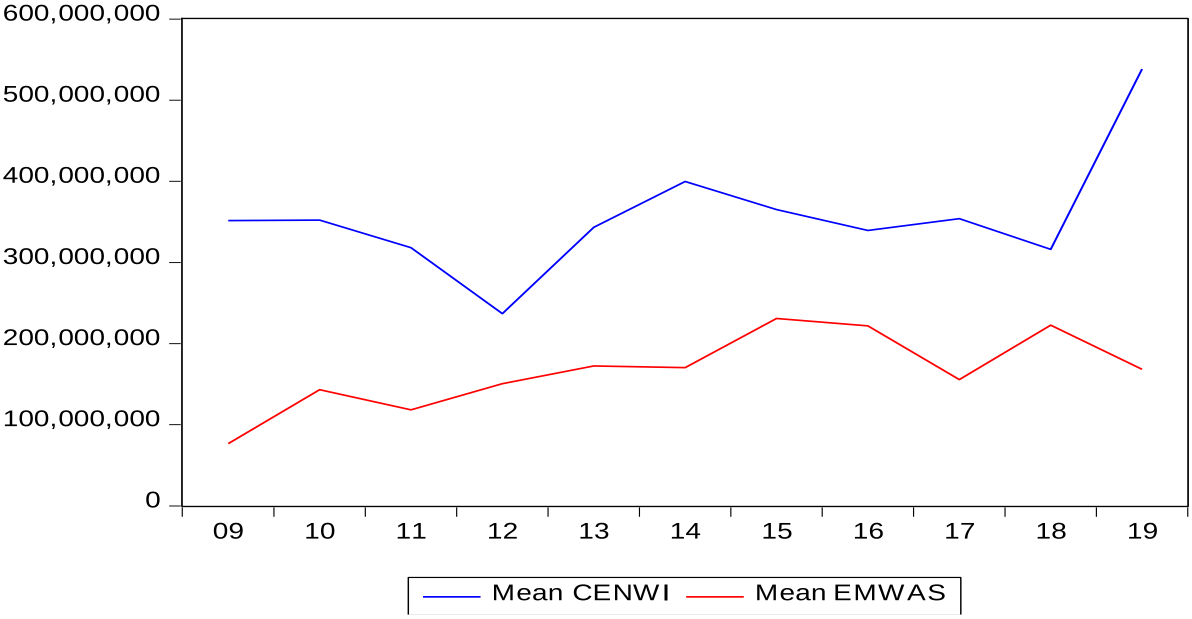

Figure 4. 2: Trend analysis for EMWAS and CENWI across all eight sSAMMs

Sources: Researcher’s construct.

In CEMWI, the years from 2010 to 2012 saw a sharp downward trend with the lowest point reaching slightly above R200million. From 2012 to 2014, the EMWAS reached an amount of R400million before it slightly dropped in R320million in 2018. However, the trend line further dropped to R150million in 2017 before rising in 2018. After 2018, CENWI sharply increased to more than R500million while EMWAS dropped slightly to below R150million in 2019.

As illustrated in Figure 4.2, most SAMMs continued to increase their budgets towards EMWAS from 2009 to 2019. However, the surge in the level of EMWAS across the metros indicates that some municipalities tried to address the problem of repairs and maintenance, which the literature has confirmed as the primary deterrent factor in addressing WSDCs (Mercer, 2018). In 2017, a sharp drop in EMWAS was experienced, but showed a constant increase during other years. On EMWAS, the size of fluctuations suggests a lack of consistency in budgeting for new water infrastructure development. Despite fluctuations, the metropolitan councils through the national government have shown a commitment to expanding the SWIF across the municipalities by continuously increasing the EMWAS. For the period 2009 to 2019, both CENWI and EMWAS showed an overall increase. The increase in IWM might be attributed to the National Water Investment Framework introduced in 2017 (DWS, 2017a). In this same context, contrary to the improvements in the flow of funds towards IWM, municipalities are concentrating more on acquiring new water assets at the expense of repairs and maintenance (Infrastructure Dialogue, 2015). Therefore, municipalities need to give balanced attention between expenditure on new and expenditure on existing assets as a measure to confront WSDCs.

4.3.2 Municipal trend analysis for total investment in water management (TOIWM)

The trend analysis for IWM was done based on total expenditure for both capital and repairs and maintenance. In addressing the existing WSDSs in SAMMs, the study focused more on how the cities manage their WSI and the impact of SWI factors on IWM. For the general trend analysis, see Figure 4.3.

The graph in Figure 4.3 indicates that the total IWM slightly increased to approximately R1 billion in 2010. The increase in total IWM was mostly linked to the government's infrastructure programmes that aimed to upgrade and develop effective WSDSs in preparation for hosting the 2010 soccer world cup. From 2010 up to 2012, the trend showed a downward direction before rising to R600million in 2015. However, a further sharp decrease occurred again between 2015 and 2017, with the total IWM reaching R520million. The increase in IWM during the post-2017 period is attributed to NWIF, which came into effect in 2017 (DWS, 2017a).

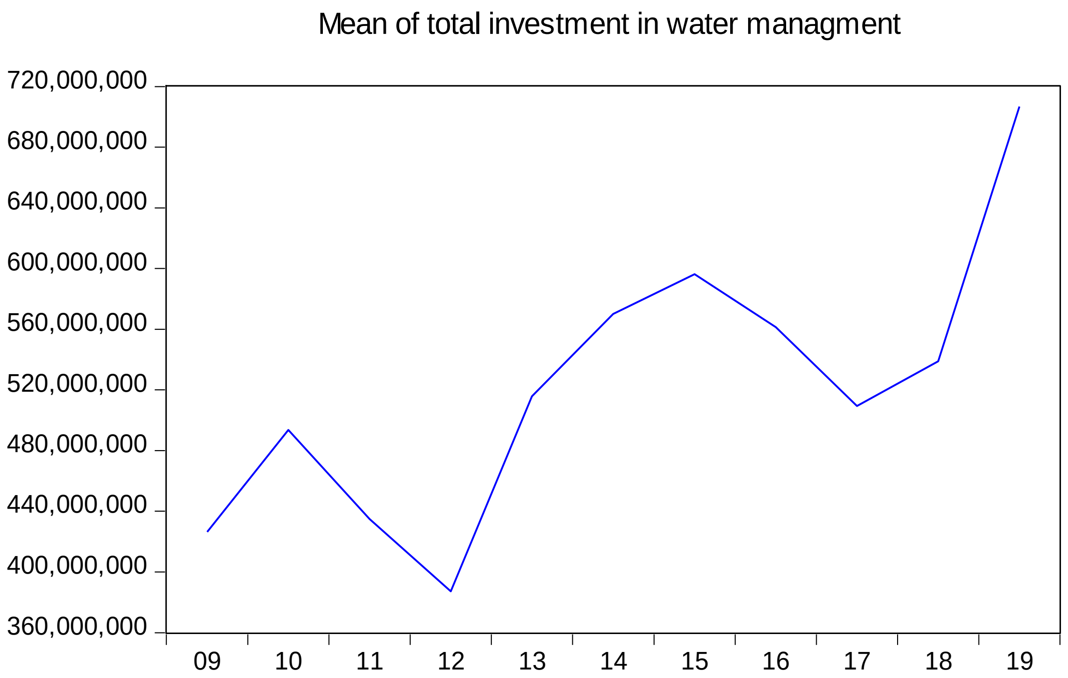

Figure 4. 3: Trend analysis for investment in water management

Sources: Researcher's construct.

Despite the increase in IWM in the SAMMs, WSDCs are far from over. According to the DWS's (2017a) ten-year infrastructure cost plan, the government requires an investment of 899 billion, but only 63% of the required amount is said to be available while 37% represents an underinvestment gap. Despite an increase in IWM, the municipalities are finding it challenging to address the persistent SWI underinvestment gap for which there are many reasons including poor corporate governance practices (CGPs) (AG SA, 2019), unprecedented levels of NRW water and poor asset maintenance (Masindi & Duncker, 2016). Therefore, the government's failure to close the funding gap further proves that certain factors beyond its control are derailing the investment efforts to address WSDCs.

4.3.3 Municipal trend analysis for social practices' variables in SAMMs

According to the literature, social factors play an essential role in providing water and sanitation services (De Carvalho *et al.*, 2009). For this study, trend analysis for social factors was performed by determining the expenditure on housing opportunities created (EHOCR) and the pipe-borne water access rate (PBWAR). In addressing the WSDCs through seeking practical ways of managing WSI, the researcher found it necessary to analyse the movement of variables in question, as shown in Figure 4.4.

In Figure 4.4, the trend line for EHOCR shows that in 2009 approximately R200million was spent before it dropped to close to R100million in 2011. After 2012, the expenditure rose to R400million in 2014, it dropped to less than 2billion in 2016. A sharp upward trend was again experienced as from mid-2016 to 2018 before it started dropping to R4.5billion. In considering the general direction of the trend line, the metropolitan councils showed some commitment towards alleviating the housing shortage problem as evidenced by the upward direction of the trend line.

Despite the general increase in housing expenditure, sharp fluctuations displayed on the graph further prove a lack of consistency concerning allocating funds required to address housing problems.

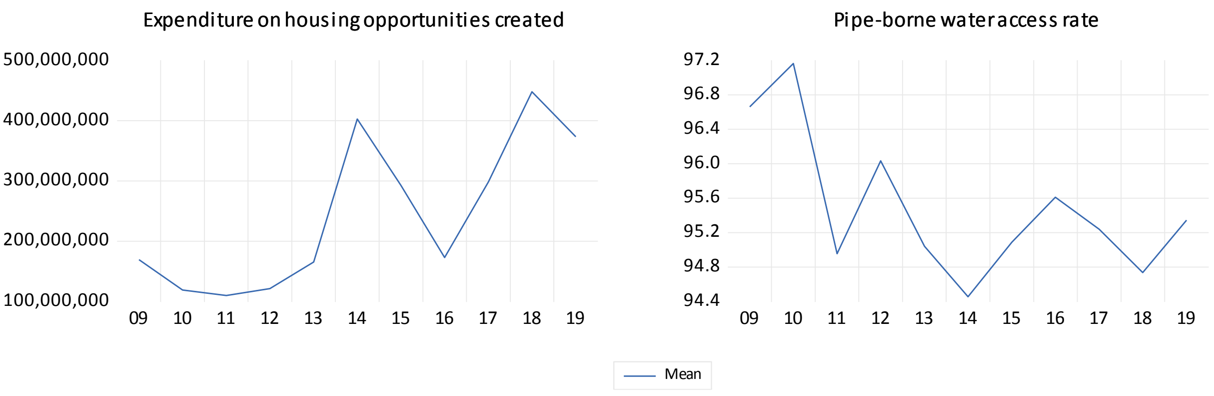

Figure 4. 4: Trend analysis for social factors in by SAMMs

Source: Researcher's construct

Additionally, an increase in the number of informal settlements in the metro municipalities as indicated in the literature (Ogra & Onatu, 2013; Borel-Saladin & Turok, 2015) implies that municipalities are failing to resolve housing challenges.

Therefore, considering the housing backlogs in the SAMMs, more funds should be committed to developing more housing units. Hence, the IWM should be adjusted to expand the SWIF to reach out to the people in new settlements.

In terms of PBWAR shown in Figure 4.4, the measure was determined based on households' percentage with access to clean and safe drinking water within a 200m radius from their yards. In 2010, the PBWAR in the SAMMs was close to 97.2%, implying a significant improvement compared to the pre-independence period. However, from 2010 to 2011, there was a sharp decrease before it increased again to 96% in 2012. The trend remained unstable as a sharp drop was experienced in 2014 (94.4%), followed by an increase in 2016 with a subsequent decrease once more in 2018 before it began picking up in 2019. Assessing the general trend for PBWAR, it is essential to note that WSDCs in municipalities persist. Apart from the earlier studies confirming the prevalence of WSDCs (Masindi & Duncker, 2016; Morudu, 2017; Weaver *et al.,* 2017), the fluctuating trend for PBWAR also persist. The prevailing WSDCs in cities signify the violation of the Constitution of the Republic of South Africa 106 of 1996, which regards water as a fundamental human right. Therefore, measures should be put to eradicate the existing WSDCs, particularly in vulnerable communities within cities.

4.3.4 Municipal trend analysis for CGPs' variables in SAMMs

Good corporate governance practices (CGPs) in the local municipalities have been singled out as the primary determinant of achieving effective and efficient WSDSs in cities (Maclean, 2015). For this study, trend analysis for governance factors was done on selected measures, namely the number of water professionals and technicians (WPTSE) and women in managerial positions including female councillors (WOGOS) from 2009 to 2019. (see Figure 4.5).

In this case, only employees working for the water department or state-owned company registered with the South African Council of Engineers (SACE) were considered as water experts. The graph below on the left-hand side shows the changes in the number of water experts serving in the SAMMs.

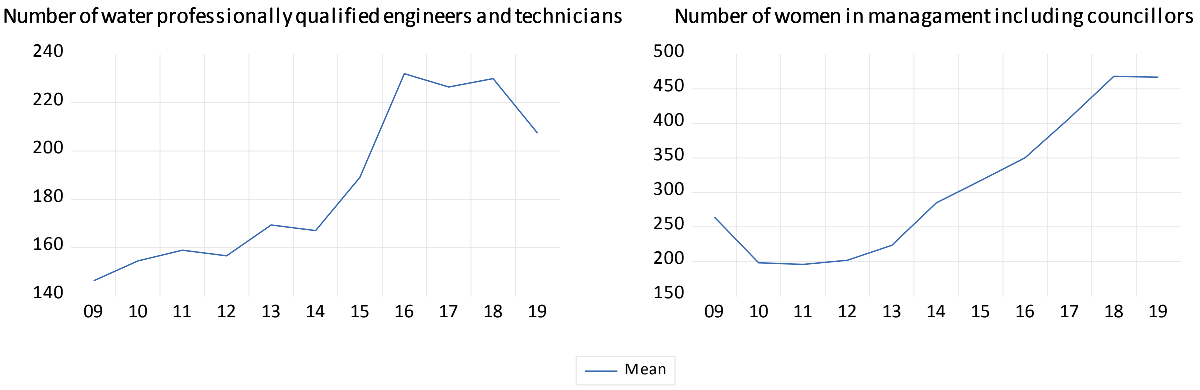

Figure 4. 5: Trend analysis for governance factors by SAMMs

Source: Researcher's construct

The trend analysis shown in Figure 4.5 illustrates the general increase in the WPTSE during the period 2009 to 2014, with a sharp increase experienced from 2014 to 2016 as the number of water experts reached 230. The post-2016 period was characterised by a decrease in water experts' number in 2019 (210). Overall, the graph's information proved that the metropolitan councils worked towards improving human capital in the water and sanitation department. The increase in water experts was in response to skills deficient challenges confronting municipalities in South Africa and the need to eradicate WSDCs challenges as confirmed in the literature (Infrastructure Dialogue, 2015; ECSA, 2016). The fact that these municipalities were on the trajectory of upskilling their employees is a sign of unwavering commitment towards addressing human capital problems that have continued to compromise essential service delivery quality. Considering the reduced functionality of SWI linked to poorly scheduled repairs and maintenance programmes and an ineffective workforce, measures should be put to continue recruiting qualified personnel to manage WSDSs across cities. However, by employing more water experts, the municipalities should brace themselves for an increased IWM as remuneration packages to attract more professionals.

For this study, women in managerial positions included only female employees serving in the top, middle and lower-level management and females serving as councillors in the metro municipalities were considered. The trend analysis for the number of women in leadership positions shows that in 2009 the average number of women was above 250, and it dropped to

200 in 2010, where it remained constant for consecutive years. From 2013 onwards, there was an increase in the number of women to above 450 in 2018. The general increase in the number of women, as shown in Figure 4.5 is a clear sign of a paradigm shift in promoting females' participation and inclusion in management. Perhaps the influence of previous studies acknowledged that the presence of women in the local government plays a critical role in promoting accountability and transparency (Araujo & Tejedo-Romero, 2018; Brenya e*t al.*, 2015), contributed to the promotion of gender equity. Therefore, the SAMMs' gender transformation policies prove to be progressive as more women leaders are now emerging. However, it is yet to be known if women's influence in the top management has had a significant influence on IWM in SAMMs.

4.3.5 Municipal trend analysis for economic practices's variables in SAMMs

Economic factors play an essential role in the management of WSI. In this case, two proxies of economic factors were considered. Firstly, non-revenue water (NREWA) represents water lost through theft, leaks, and burst pipes, which resulted in economic losses to the municipalities. Secondly, the net operating surplus margin (NOSMA) was considered one of the FP ratios that measure municipalities' efficiency. Trend analysis for the NREWA and NOSMA is shown in the graphs given in Figure 4.6. In 2009, the average percentage of NREWA was around 34% before it increased to nearly 35% in 2010. However, efforts were made, and the NREWA decreased to below 34% before it sharply rose to more than 37% in 2015.

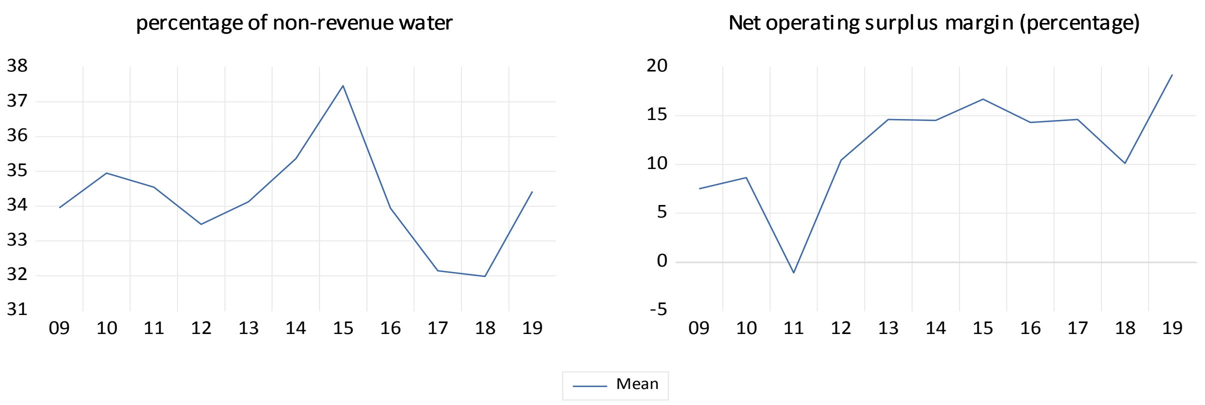

Figure 4. 6: Trend analysis for economic factors by SAMMs

Source: Researcher's construct

The high levels of NREWA in the metros during 2015 completely changed the government approach towards water accountability and management. The reduction in NREWA after 2015 might be attributed to an increase in water experts, as shown in Figure 4.6. The level of NREWA dropped to 32% in 2018, and after that it rose again in 2019.

Though the level of NREWA continuously fluctuated during the period under review (2009 to 2019), the overall trend suggests a slight decrease. However, measures need to be put in place to decrease the amount of unaccounted water as various studies have pointed out that NREWA has a detrimental effect on local governments' financial and service delivery performance (Murrar *et al.*, 2017; Yazid *et al.*, 2017). The robust FP of municipalities is imperative for the effective management of SWI in the local municipalities. Therefore, more emphasis should be on reducing NREWA to avoid economic losses that might negatively influence IWM in SAMMs.

The trend analysis for the NOSMA is shown in Figure 4.6. In 2009 and 2010, the NOSMA was above 5% and subsequently followed by a sharp drop in 2011. After 2011, the NOSMA increased to 17% in 2015, followed by a four-year downward trend ending in 2018 after reaching the 10% mark. In 2019, it rose again to 19%, and this further implied that water entities or departments can generate more income if adequately managed. Based on the general increase in NOSMA over the years in question, it is evident that municipalities greatly improved managing water revenue collection. Therefore, water services authorities should ensure that the dependency syndrome on government transfer is gradually eliminated through enforcing economic factors that promote financial viability and independence in municipalities.

4.3.6 Municipal trend analysis for EMPs' variables in SAMMs

Concerning trend analysis for environmental management factors, selected proxies were used, namely expenditure on environmental protection management (EOEPM) and wastewater management expenditure (EOWWM). In EOEPM, only expenditure on improving biodiversity and pollution control activities in SAMMs was considered. The EOWWM was measured through funds expensed on the treatment of wastewater generated from water and sanitation activities. The trend analysis for the variables is based on the interpretation of the graphs in Figure 4.7.

Figure 4.7 shows that in 2009 EOEPM was below R80million and rose to R140million in 2010 before it decreased again in 2011. The EOEPM rose to R100million in 2014 and after that dropped to less than R100million in 2017. The trend line continued to fluctuate, with a slight increase in the aftermath of 2017.

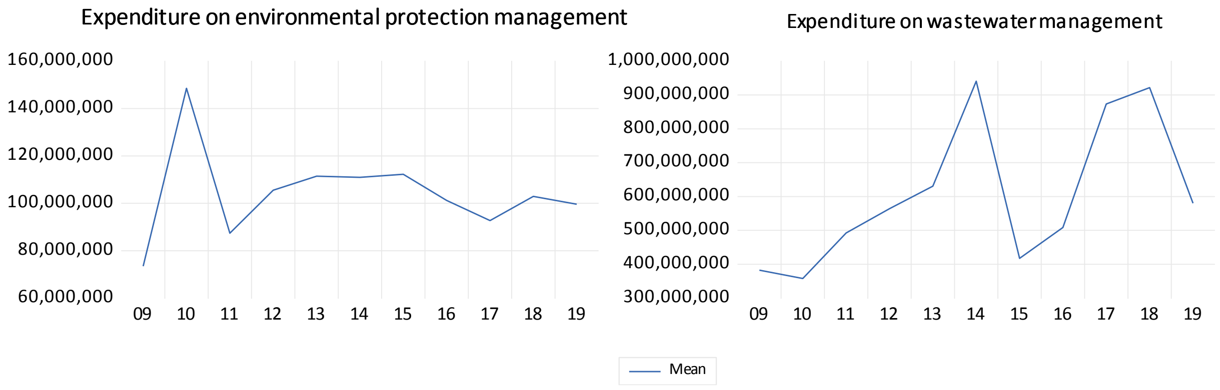

Figure 4. 7: Trend analysis for environmental factors by SAMMs

Source: Researcher's construct

In focusing on the trend analysis, there was a slight general increase in EOEPM during the review period. The slight improvement in environmental protection expenditure points to the fact that the metropolitan municipalities have begun to show concern for environmental issues that trigger climate change effects. Failure to speedily deal with poor environmental management practices (EMPs) can contribute to inefficiencies and ineffectiveness in the functionality of SWI through triggering climate change effects such as high temperatures, flood, storm weather that induces risks to the existing WSDSs (Schweikert *et al.*, 2014; Nel & Denoon-Stevens, 2015). Therefore, municipalities need to work on measures to mitigate the impacts of climate change effects on sustainable water management functionality and so create stability to the IWM.

The treatment of wastewater is critical to saving human lives and keeping the environment clean. About the information displayed in Figure 4.7, from 2010 to 2014, EOWWM increased from R380million to R920million. After this, it decreased to R410million in 2014 before a further increase of approximately R90million in 2018. Overall, during the period under review, a remarkable increase in EOWWM was witnessed. However, of great concern are significant fluctuations of the trend line which justifies inconsistencies in EOWWM across the metropolitan municipalities during the study. The sharp increases and decreases characterising the trend line resonates with the study results of Naidoo *et al.* (2016) who found out that municipalities lack resources to invest in wastewater leading to ineffectiveness in producing the right quality water. Therefore, it is critical for metro municipalities to ensure that the required level of EOWWM is maintained to prevent the unnecessary cost of decontaminating contaminated water sources. For example, in the Vaal River, water was contaminated because the failure of the surrounding municipalities to manage wastewater, and it resulted in municipalities incurring the unnecessary cost of hiring more experts to address the problems that were deliberately created.

4.3.7 Descriptive statistics

In this section, descriptive statistics were generated from panel data gathered from reports generated by eight SAMMs for the period ranging from 2009 to 2019. The descriptive statistics of the thirteen variables employed in the study are presented in tabular format. As shown in Table 4.1, 88 observations comprised the panel dataset. The data regarding capital expenditure on new water assets (CENWI) showed a mean of R356m, while the standard deviation was R334m.

The maximum expenditure on new water assets (EMWAS) was R1.8b, and the minimum was R7m. However, the standard deviation is small compared to the mean, it implies that most of the data variables are clustered around the mean.

This further suggests that there was not much difference in CENWI in the metropolitan municipalities in question. Concerning the EMWAS, the maximum and minimum of R677m and R12m, respectively, were recorded. The mean value was R166m which is smaller than the standard deviation of R168m, and this implies a slight data variability across metropolitan municipalities. The total IWM variable showed a mean (R522m) smaller than the standard deviation of (R435m). This confirms low variability in terms of IMW across all eight metropolitan municipalities involved.

The maximum expenditure on housing opportunities created (EHOCR) was R1.4b, and the minimum was R0.3m. The mean EHOCR created was R243m which was less than the standard deviation of R311m, meaning there was little variability in housing expenditure across the municipalities in question. Regarding other variables for social practice, namely, for the pipe-borne water access rate (PBWAR), the mean value was 95.44% which was much bigger than the standard deviation of 4.48% implying a low coefficient of variation across the metropolitan municipalities involved. In contrast, the maximum was 100% and the minimum 81%, meaning there is the presence of outliers in the data points.

Table 4. 1: The summary statistics of variables

Variables	**Mean**	**Maxi**	**Mini**	**Std. Dev.**	**Obs**
Capital expenditure on new water assets	R356m	R1,87b	R7m	R334m	88
Expenditure on the maintenance of water assets	R166m	R677m	R12m	R168m	88
Total investment in water management	R522m	R2,34b	R21m	R435m	88
Expenditure on housing opportunities created	R243m	R1,40b	R0,3m	R311m	88
Expenditure on environmental protection management	R104m	R583m	R8,6m	R81m	88
Expenditure on wastewater management	R606m	R3,52b	R12m	R698m	88
Total value of assets	R38b	R95,4b	R3,5b	R22,2b	88
Net operating surplus margin	11.78	71.07	-56.4	22.8	88
Percentage of non-revenue water	34.22	52.2	11.65	8.15	88
Percentage of households with access to pipe-borne water	95.48	100	81.05	4.84	88
Number of women in management: female councillors	307.09	1410	39	330.89	88
Number of water professionals and technically skilled employees	185.23	545	43	113.91	88
Population Size	2,6m	5,7m	0,7m	1,5m	88

Source: Researcher’s construct

The highest expenditure on wastewater management (EOWWM) recorded was R3.52b and the minimum of R12b. The mean EOWWM was R606m which was smaller than the standard deviation of R698m, and this implies a significant variation on EOWWM existed across the metropolitan municipalities. The mean for expenditure on environmental protection management (EOEPM) was R104m, with the standard deviation of R81m, and this suggests a low degree of variance across the metropolitan municipalities. The maximum expenditure recorded was R583m and the minimum R8.6m, again implying the presence of outliers within the dataset.

The women in management (WOGOS) data recorded a mean of 307.091, and the standard deviation was confirmed to be 330.89. However, the higher variance than the mean implies a high variation in women's participation in the management of the metropolitan councils. The recorded maximum and minimum values 1410 and 39 suggest that outliers do exist in the data points. In the context of water experts employed by the municipalities, the maximum and minimum recorded were 545 and 43. The mean and the standard deviation of 185.239 and 113.929, respectively, implying a low coefficient of variation across the municipalities. The maximum and minimum percentages of NREWA were 52.2 and 11.65, respectively. In the case of the mean for NREWA, 34.22% was recorded which was greater than the variance of 8.15%, implying a low coefficient of variation across the metropolitans in South Africa. Lastly, for net operation surplus margin (NOSMA), the standard deviation was 22.80%, and it is twice the mean of 11.78 meaning that data points are not clustered around the mean and confirm the presence of a high variation in the (NOSMA) in SAMMs.

4.4 BIVARIATE ANALYSIS

In this regard, the bivariate analysis presents information in tables showing the relationship between two variables. Firstly, the correlations matrix presents results concerning the correlations between the independent variables and then followed by analysing the relationship between each independent variable against each dependent variable.

4.4.1 Correlation matrix

Correlation analysis indicates the direction and strength of the relationship between the two paired variables (Mutezo, 2015). Determining the relationship between the variables is essential in understanding why relationships exist and the likelihood of affecting inferential statistics. Table 4.2 presents pairwise correlation coefficient results between two variables, and +/- signs represent positive and negative correlation, respectively, which is the direction of the relationship. In terms of the strength of the linear relationship, a correlation coefficient greater than 0.8 showed a strong correlation, which is a sign of the presence of multicollinearity; while values close to zero represent a weak linear relationship.

Table 4. 2: The correlational matrix for independent variables

	Ehocr	Pbwar	eoepm	Eowwm	Nosma	Nrewa	Wogos	wptse	popsz	tvass
Ehocr	1									
Pbwar	-0.014	1								
Eoepm	0.221	0.028	1							
eowwm	0.444	0.049	0.149	1						
Nosma	0.213	0.096	-0.032	0.060	1					
Nrewa	-0.276	0.120	-0.129	-0.226	-0.110	1				
Wogos	0.500	-0.208	0.279	0.495	-0.119	-0.079	1			
Wptse	0.339	-0.199	0.153	0.227	0.286	-0.749	0.055	1		
Popsz	0.508	-0.188	0.404	0.508	-0.015	-0.468	0.740	0.490	1	
Tvass	0.501	-0.187	0.295	0.428	-0.048	-0.328	0.795	0.359	0.886	1

Source: Researcher's construct

As depicted in Table 4.2, EHOCR is negatively correlated with PBWAR and NREWA. However, this implies that any increase in EHOCR is automatically translated into a decrease in PBWAR and NREWA. EHOCR showed a positive and weak association with EOEPM, NOSMA and WPSTE. Similarly, PBWAR showed a weak and positive relationship with EOEPM, EOWWM, NOSMA and NREWA. The PBWAR showed a negative correlation with WPTSE and WOGOS. Though correlation coefficients (less than 0.3) showed a weak relationship, it has been found that a positive correlation existed between EOEPM and the three variables, namely WOGOS, WPTSE and EOWWM. Furthermore, NREWA and NOSMA have had a weak and negative correlation with EOEPM. EOWWM showed a positive relationship with NOSMA, WOGOS and WPTSE except with NREWA, which showed a relatively weak negative association. NREWA proved to have a negative association with NOSMA and NREWA and on the same note showed a negative association with WPSTE. Concerning

NREMA, a strong and negative association existed between WOGOS and WPTSE. Finally, a moderately positive relationship between WOGO and WPSTE was found. However, a significant concern is the strong correlation between the control variables, namely the total value of assets (TVASS) and population size (POPSZ). Overall, the correlation results showed that most of the variables showed very weak to moderate correlations, implying that the panel data turned out to be free of the problem of multicollinearity.

4.4.2 Examining the impacts of independent variables on each dependent variable

Bivariate analysis is a statistical procedure that involves the analysis of two variables: the independent and dependent variables, to determine the relationship. In this case, bivariate analysis was used to evaluate the strength and direction of the relationship between each independent variable and each dependent variable. Before the bivariate analysis was done, EMWAS, CENWI, TOIWM, EOEPM, EHOCR and EOWWM were transformed to remove the systematic change in the spread to achieve approximate homoscedasticity (Warner, 2012). Table 4.3 shows the bivariate analysis's statistical results between expenditure on maintenance of water assets (EMWAS) and each of the eight independent variables.

4.4.2.1 Bivariate analysis for EMWAS and all predicators

The EMWAS was regressed over each independent variable, as shown in Table 4.3. The outcome of the relationship between EHOCR and EMWAS suggests that the SAMMs have shown a commitment to addressing the functionality challenges confronting the existing SWI, as indicated in the literature (Infrastructure Dialogue, 2015).

This was done by increasing EMWAS to match with EHOCR as a strategy to avoid infrastructure neglect. However, for the association between PBWAR and EMWAS, the outcomes were negative (-2.02.1) and insignificant. The results imply that congruence is lacking between EMWAS and PBWAR, and this might have resulted in infrastructure neglect as the municipalities kept on concentrating on expanding the SWIF at the expense of existing out-dated water infrastructure. The negative relationship might be attributed to poor CGPs with strong links with the existing WSDCs (Morudu, 2017). Therefore, putting greater emphasis on repairs and maintenance is fundamental in avoiding a cut in existing water assets' life span. The relationship between expenditure on environmental protection management (EOEPM) and EMWAS turned out to be positive (0.31**) and significant at a 5% significant level. The results suggest that EOEPM has had a positive influence on EMWAS and resonates with the recommendations of various studies concerning the elimination of poor EMPs that are detrimental to the functionality of WSI (Chinowsky *et al.*, 2015; Ali *et al.*, 2019).

Table 4. 3: Bivariate analysis for EMWAS and SWI factors

	-1	-2	-3	-6	-7	-8	-9	-10
variables	Emwas	Emwas	Emwas	emwas	emwas	emwas	emwas	emwas
Ehocr	0.114*							
	-0.063							
Eowwm		0.0931						
		-0.111						
Eoepm			0.31**					
			-0.131					
Pbwar				-0.0201				
				-0.023				
Wogos					0.001***			
					-0.0003			
Wptse						0.0008		
						-0.0009		
Nosma							-0.0014	
							-0.005	
Nrewa								-0.020
								-0.014

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher’s construct

In the link between EOWWM and EMWAS, the outcomes were positive (0.0931) and insignificant. The results suggest that even though funding challenges exist, SAMMs have tried their best to comply with the environmental regulations by ensuring that distributing channels for wastewater remained optimally functional. Therefore, SAMMs increased their budgets for EMWAS to show a significant commitment towards countering environmental hazards which could be climate change effects that might pose risks to the malfunctioning SWI.

In the relationship between WOGOS and EMWAS, a positive (0.001***) and highly significant at 1% outcome was found. The results suggest that increased women's participation in the local government administration has influenced the funds' allocation towards repairs and maintenance. Proper management of repairs and maintenance is fundamental in keeping SWI functioning properly and reducing the impacts of the WSDCs. The results also resonate with the previous studies' results, which acknowledged that the involvement of women in the local government's top management structures is critical for the proper governance of WSDSs (Adnan *et al.*, 2013; Ng'etich, 2015). An insignificant and positive (0.0008) relationship was found between the numbers of WPSTE and EMWAS. In this regard, the quality of human resources has had a slightly positive influence on EMWAS. The results are consistent with Monkam's (2014) results regarding the positive influence of quality human capital in management and administration on the productive efficiency of the municipalities. Therefore, in the context of existing SWI challenges, increasing the number of water experts was an essential contributor towards resolving problems such as water pipe leaks, burst pipes and water theft to create a stable water investment environment.

Concerning the nexus between NREWA and EMWAS, negative (-0.0204) and insignificant results were found. The outcomes imply that an increase for unaccounted water has had a complete reversal effect on the EMWAS. The existing water loss problems were not taken seriously by SAMMs as EMWAS was supposed to have been increased to counter the high levels of unaccounted water. The results correspond with Yazid *et al.* (2017), who found that NREWA has continued to influence the water value chain and financing negatively. Without exception, metropolitan cities must increase their budgets on EMWAS to help reduce NREWA, which leads to economic losses. Furthermore, the NOSMA and EMWAS relationship turned out to be insignificant and negative (-0.005). The outcomes suggest that metropolitan councils might have emphasised surplus maximum at the expense of investing in repairs and maintenance. The results are contrary to Başci and Başci (2016) , who found that a positive FP influence had a positive effect on investment in drinking water. Therefore, in this regard, surplus income should be channelled towards increasing EMWAS as a measure to eliminate WSDCs in SAMMs.

4.4.2.2 Bivariate analysis for capital expenditure of new assets and all predicators

This section discusses the bivariate analysis results for CENWI and all independent variables. The results of the bivariate analysis are shown in Table 4.4. Bivariate analysis involving examining the relationship between EHOCR and CENWI as an independent variable established a highly significant and positive relationship, as evidenced by the regression coefficient of 0.220***. However, the results suggest a true reflection of what is happening on the ground as more housing units are being built. There is a need to expand the SWIF to reach out to the new housing occupants.

For the relationship between PBWAR and CENWI, the results turned out to be negative (-0.025) and insignificant. The results indicate that changes to PBWAR did not positively influence CENWI as clearly and that municipalities mostly concentrated on developing new water infrastructure to establish new water connections to the residents occupying the new settlements. Therefore, the municipalities must allocate more funds towards acquiring new water assets to improve water accessibility in the existing settlements.

The EOWWM and CENWI connection happened to be positive (0.257**) and significant at 5% significant level (as shown in Table 4.4). The positive outcomes further indicate that EOWWM influences investment in new water infrastructure assets positively. While in the case of EOEPM, the regression coefficient of 0.486***depicts a positive and strongly significant relationship at a 1% significant level.

Considering the positive impacts of both EMPs on CENWI, the municipalities might have realised the negative impacts of poor EMPs associated with climate change effects as indicated in the literature (Schweikert *et al.*, 2014). On the same note, positive results resonate with Ali *et al*. (2019) who found a positive relationship between EMPs and sustainable performance in Malaysia. Therefore, the municipalities should continue with their strategies of employing good EMPs as envisaged in the sustainable development road map (Osborn *et al.*, 2015) to develop sustainable cities free of WSDCs.

Table 4. 4: Bivariate analysis for CENWI and all predicators.

Variables	-1 Cenwi	-2 Cenwi	-3 Cenwi	-6 Cenwi	-7 Cenwi	-8 Cenwi	-9 Cenwi	-10 cenwi
Ehocr	0.220***							
	-0.06							
Eowwm		0.257**						
		-0.108						
Eoepm			0.486***					
			-0.124					
Pbwar				-0.025				
				-0.023				
Wogos					0.001***			
					-0.000			
Wptse						0.004***		
						-0.0008		
Nosma							0.008*	
							-0.004	
Nrewa								-0.04***
								-0.0129

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

The WOGOS has had a highly significant (0.001***) and positive impact on CENWI, implying that an increase in the number of women involved in the administration of local governments positively influenced the allocation of funds used to acquire new assets. The results also agree with other studies that appreciated female representation within the management structures of local municipalities (Adnan *et al.*, 2013; Ng'etich, 2015). The outcomes were highly significant and positive regarding the nexus between the WPTSE and CENWI (0.004***). However, the positive outcomes suggest that water experts have influenced local municipalities to invest more in new water assets to replace outdated water infrastructure. Alternatively, water experts influenced the local authorities to invest more in new water assets to address the existing SWI backlog. Therefore, municipalities must continue to increase their investments in acquiring new water assets to eliminate all WSDCs derailing progressive efforts towards creating sustainable cities.

The relationship between NOSMA and CENWI turned out to be positive and weakly significant (0.008*) at a 10% significance level. The results suggest that the FP of the water and sanitation department's metros municipalities did cause a slightly positive effect on CENWI. Thus, to a certain extent, SAMMs have invested funds generated from their fiscal activities in acquiring new water assets as a strategy to close the existing SWI underinvestment gap which has been confirmed in various studies as a significant obstacle in addressing WSDCs (Ruiters & Matji, 2015; Masindi & Duncker, 2016). Concerning the impact of NREWA on CENWI, the regression coefficient of -0.04*** proves a highly significant negative relationship. The results indicate that the increase in NREWA did not trigger municipalities to invest in acquiring new water assets as expected. Besides, the negative outcome is a clear indication of what is happening on the ground concerning a high level of NREWA which several studies alluded to as a significant problem in maintaining a healthy financial state in municipalities (Mckenzie, 2014; Infrastructure Dialogue, 2015; Msomi, 2015). Therefore, efforts should be made to address the problems of high quantities of unaccounted water to achieve stability in the management of water investments.

4.4.2.3 Bivariate analysis for total IWM and all predicators

The bivariate analysis examined the relationship between total (total investment in water management) TOIWM and SWI factors. The results are presented in Table 4.5. The relationship between EHOCR and TOIWM was found to be positive (0.207***) and highly significant at a 1% significant level. However, the same positive results were confirmed in Table 4.3 and 4.4, and this suggests that changes in EHOCR and TOIWM moved in the same direction.

The results resonate with Glossop (2008), who confirmed that housing development projects have had a positive effect on attracting investments in the city of London. Concerning another social practice factor, PBWAR has had a negative (-0.026) and insignificant effect on TOIWM in the SAMMs, and this also resonates with the previous bivariate analysis result (shown in Table 4.3 and 4.4). However, this further proved that changes in PBWAR failed to positively influence IWM, and thus, explains the prevalence of WSDCs in the South African cities (Infrastructure Dialogue, 2017).

Table 4. 5: Bivariate analysis for TOIWM and all predicators.

Variable	-1 Toiwm	-2 Toiwm	-3 Toiwm	-6 Toiwm	-7 Toiwm	-8 Toiwm	-9 toiwm	-10 Toiwm
Ehocr	0.207*** -0.054							
Eowwm		0.215** -0.098						
Eoepm			0.477*** -0.111					
Pbwar				-0.026 -0.021				
Wogos					0.00*** -0.000			
Wptse						0.00*** -0.000		
Nosma							0.002 -0.004	
Nrewa								-0.04*** -0.01

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher’s construct

Therefore, measures must be in place to ensure that the water access backlog receives adequate investment backing to eliminate the existing WSDCs characterising cities.

Regarding how EOWWM influenced TOIWM in municipalities, the bivariate analysis confirmed a positive (0.215**) and significant relationship at a 5% significant level. The same results were found in Tables 4.3 and 4.4, implying that EOWWM has had a positive effect on municipals' decisions to focus on both EMWAS and CENWI. On the other hand, EOEPM significantly and positively (0.477***) influenced TOIWM, and the results are consistent with prior bivariate analysis results displayed in Tables 4.3 and 4.4. The results confirmed the position of the SAMMs regarding promoting good EMPs to mitigate climate change-induced risks that have the potential to disturb the functionality of WSDSs as alluded to in the literature (Esterhuyse, 2012; Van den Berg, 2014; Nel & Denoon-Stevens, 2015).

In light of the results, it is clear that SAMMs is acknowledged in the results of He *et al.* (2017). They found that local government investments have significantly reduced carbon emissions by adopting the same approach to reduce climate change effects. These climate change effects might trigger destructive actions to sustainable water management, resulting in an increased IWM. Therefore, an appropriate approach of promoting EMPs in municipalities must be intensified across the country to seek sustainable solutions to existing WSDCs in cities.

In terms of the association between WOGOS and TOIWM, the outcomes turned out to be positive and highly significant (0.00***), thus suggesting that women's participation in local government affairs administration was critical in influencing IWM. As shown in Table 4.5, the results do not deviate from other bivariate analysis results given in Tables 4.3 and 4.4, which also had positive outcomes. Similar studies acknowledged women's presence in the management structure of local municipalities as a progressive approach towards water services performance (Ng'etich, 2015; Brenya *et al.*, 2015). After evaluating the relationship between WPTSE and TOIWM as positive (0.00***), highly significant results at 1% were found. The outcomes were a true reflection of the municipalities' approach towards addressing the skills shortage. They hired more water experts to counter SWI functionality challenges that often lead to WSDCs. SWI functionality challenges are exhibited by water pipe leaks, burst pipes and water theft, and they are significant obstacles to achieving favourable FP in municipalities (Murrar *et al.*, 2017; Yazid *et al.*, 2017). Therefore, approaches such as appointing more women and water experts must be intensified to influence IWM further to address the long-standing battle with WSDCs in cities. The relationship between NREWA and TOIWM produced a positive and highly significant (-0.04***) outcome. The negative results are consistent with preliminary bivariate analysis (see Tables 4.3 and 4.4), which found that NREWA has had regressive effects on both EMWAS and CENWI. As such, the high rate of NREWA in SAMMs is justified as insufficient investment concentration was given to the management of new water assets. However, if adequate attention was given, the level of unaccounted water could have declined. These results coincide with Güngör-Demirci *et al.* (2018) who found that NREWA harmed FP through reduced potential revenue. Lastly, NOSMA as a financial efficiency indicator representing FP in municipalities was found to have positive (0.002) and insignificant effect on TOIWM. In light of the results, this suggests that the surplus income generated only influenced CENWI positively, thus suggesting that the excess surplus might have been used to purchase new water assets at the expense of repairs and maintenance costs. The results resonate with Başci and Başci (2016) previous work, which established that good FP has had a positive effect on drinking water investment in 81 Turkish municipalities. Therefore, for municipalities to be financially and economically sustainable to enhance IWM and close the SWI underinvestment backlog, more attention should be channelled towards reducing NREWA and promoting sound FMPs.

The overall results shown in Table 4.5 suggest that most of the variables (EHOCR, EOWWM, EOEPM, WOGOS, NREWA & WPSTE) have had a positive influence on TOIWM in the SAMMs, except NOSMA and PBWAR. The results reflect pairwise correlations involving two variables only. Hence, these results are a true reflection of bivariate analysis, and they are either confirmed to be accurate or inaccurate after undertaking subsequent statistical inference tests. The multivariate analysis approach was employed to confirm if the results remain consistent, given the fact that regression assumptions were observed. Therefore, the next section provides a discussion of diagnostic test results which indicate the direction as to which panel data econometric panel approach was appropriate to address the research objectives.

4.5 DIAGNOSTIC TESTS

For this study, panel data analysis was employed to examine the relationship between SWI factors and IWM in SAMMs. However, panel data has a few analytical problems that could compromise OLS results' reliance (Certo & Semadeni, 2006). Therefore, this section discusses various diagnostic tests performed to identify and correct any violation of regression assumptions. In ensuring the reliability of results from the OLS estimation model, multicollinearity, heteroscedasticity, serial correlation and normality tests were conducted before evaluating the relationship between the SWI factors and IWM in SAMMs.

4.5.1 Multicollinearity

In avoiding distortions to the standard errors caused by strongly correlated independent variables, multicollinearity tests were done to establish the presence of multicollinearity. According to García *et al.* (2015), the presence of multicollinearity among the predictor variables is not desirable because it can weaken the regression model results' statistical power.

Table 4. 6: The variance inflation factor results

	Variable	VIF	1/VIF
POPSZ	7.25	0.137959	
TVASS	5.05	0.198047	
WOGOS	3.91	0.255857	
WPTSE	3.63	0.275778	
NREWA	2.53	0.394826	
EHOCR	2.03	0.492588	
EOWWM	1.72	0.582204	
EOEPM	1.50	0.664988	
PBWAR	1.36	0.737429	
NOSMA	1.29	0.776402	
Mean VIF	3.03		

Source: Researcher’s construct

For this study, the variance inflation factor (VIF) was employed to determine the multicollinearity level among the independent variables. Table 4.6 presents the variance inflation factor (VIF) results determining if multicollinearity exists in panel data.

Table 4.6 shows that multicollinearity does not exist as evidenced by the VIF of 3.03, which is far less than 10. In most cases, a VIF of less than 10 shows lack of multicollinearity and so standard errors for the regression model results were not affected. Therefore, the absence of multicollinearity implied that the study's independent variables are not closely correlated.

4.5.2 Heteroscedasticity

Homoscedasticity is one of the regression assumptions that should be observed when dealing with panel data. Heteroscedasticity usually results in heterogeneity problems that lead to biased results and inconsistent estimates of regression coefficients which are inefficient (Baltagi, 2008). The alternative hypothesis assumes heteroscedasticity, which is undesirable, and the null hypothesis assumes that homoscedasticity is present in the dataset, which is desirable. Thus, to determine whether the data has either homoscedasticity or heteroscedasticity, the researcher did the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity. A p-value of less than 0.05 implies that an alternative hypothesis cannot be rejected. Table 4.7 shows that Breusch-Pagan/Cook-Weisberg test for heteroscedasticity.

Table 4. 7: Heteroscedasticity results

estat hettest
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of TOIWM
chi2(1) = 0.01
Prob > chi2 = 0.9252

Source: Researcher’s construct

From the results given in Table 4.7, the p-value of 0.9252 is more than 0.05, implying that that null hypothesis cannot be rejected. The results further confirm the presence of homoscedasticity, which is desirable. However, this implied that this study's results were not threatened by the problem of heteroscedasticity, which tends to create biased results.

4.5.3 Normality

Normality is one of the critical conditions of panel data that should be observed when employing pooled ordinary least square as a regression estimation model (Osborne & Waters, 2002). The data must be normally distributed to avoid producing unsatisfactory results that are characterised by the underestimation of regression estimation coefficients. To ensure that valid and reliable results were produced, the study employed two Skewness/Kurtosis tests for Normality.

Table 4. 8: Normality tests results

sktest myresidual					
Skewness/Kurtosis tests for Normality—joint-----					
Variable	Obs	Pr(Skewness)	Pr(Kurtosis) adj	chi2(2)	Prob>chi2
myresidual	72	0.0571	0.4574	4.29	0.1170

Source: Researcher’s construct

As shown in Table 4.8, Skewness/Kurtosis tests for normality show that the panel data is normally distributed as evidenced by the p-values, which are more than 0.05 significant level and therefore, the null hypothesis, which indicates that panel data is normally distributed, cannot be rejected.

4.5.4 Serial correlation

Although it is indicated that serial correlation is mostly found in time series (Born & Breitung, 2016), it has been argued that failure to observe the problem of serial correlation in panel data may result in inefficient estimates of the regression coefficient and biased standard errors (Drukker, 2003; Baltagi, 2008). For this study, Runtest for random order was employed to confirm if autocorrelation exists in the panel data. The runtest performs a nonparametric test of the hypothesis that determines if error terms are random by counting many runs above and below the threshold. The outputs of run-test were in the form of a scatter graph and table. Figure 4.8 shows the run-test to check regression residuals for serial correlation.

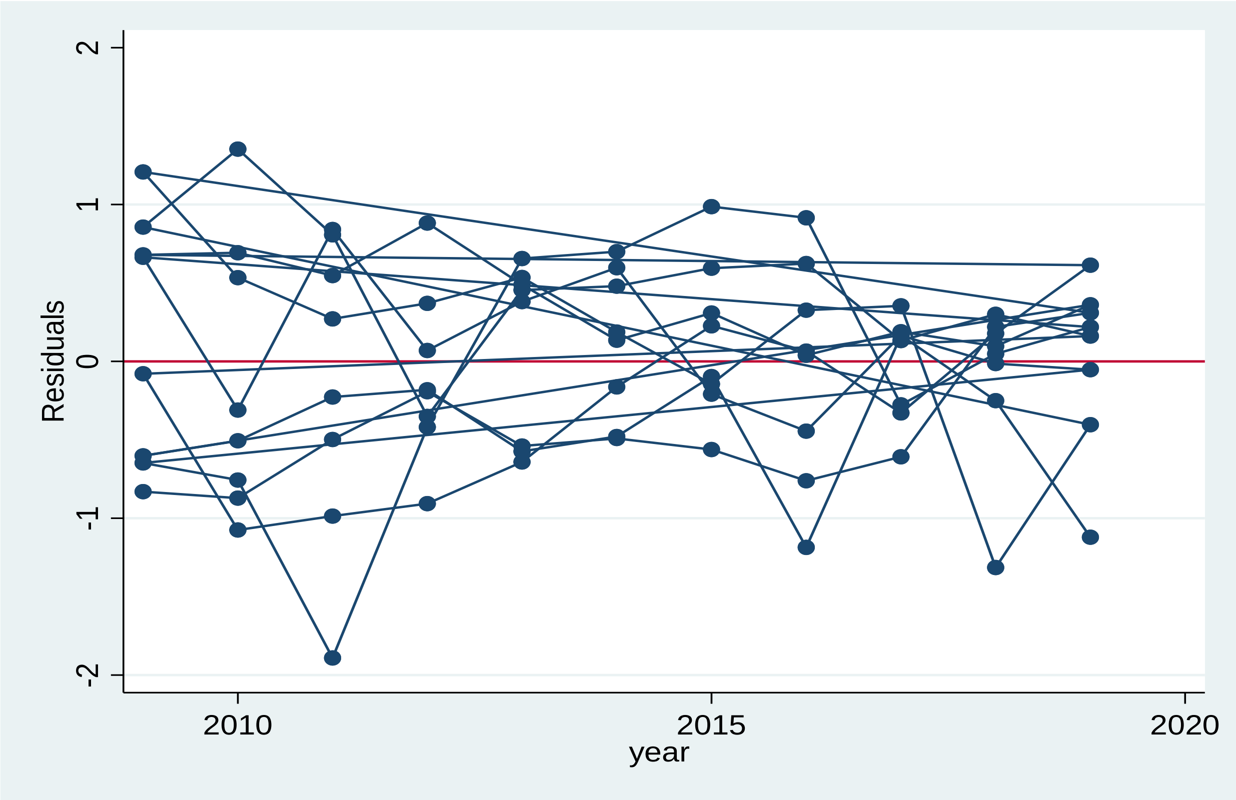

Figure 4. 8: The run-test to check the regression residual for serial correlation.

Source: Researcher's construct

As indicated in Figure 4.8, the graph gives the impression that the relationship between error terms seems to be partially random. The residuals are randomly distributed, as shown by the number of runs that move up and down the threshold. Therefore, serial correlation in the panel data was ruled out as a threat to OLS model results. In confirming the graphical presentation of serial correlation tests, runtest was used to evaluate the random regression residual's statistical significance as displayed in Figure 4.8.

The runtest results displayed in Table 4.9 show that there are 45runs in 88 observations. Building on the normal approximation to the distribution of the number of runs, in this matter, the number of runs is more than 50% of the number of observations implying that regression residuals are serially independent. The run-test results are presented in Table 4.9.

Table 4. 9: Run-test results showing statistical significance

runtest resid_D,thresh(0)
N(resid_D <= 0) = 38
N(resid_D > 0) = 49
obs = 87
N(runs) = 45
z = .26
Prob>z = .79

Source: Researcher's construct

On the same note, the p-value is 0.79, which is more than the significant level of 0.05, indicating that the null hypothesis cannot be rejected. Therefore, the problem of serial correlation was strongly ruled out as posing threats to the panel data econometric models.

4.6 MULTIVARIATE ANALYSIS RESULT

Unlike univariate and bivariate analysis, the multivariate analysis provides linear relationships involving more than two independent variables. In ensuring the adequacy of the regression models performed, checks for the violation of the regression assumption were done, as shown in the preceding section. However, it was established that the panel dataset was free from misspecifications and any form of violation, and as such, the study employed ordinary least squares (OLS) to analysis the relationship between SWI factors and IWM. Besides, feasible generalised least squares (FGLS) models were employed to augment the estimated OLS results to ensure the robustness of the testing procedures employed.

4.6.1 Examine the relationship between corporate governance practices and IWM

Table 4.10 shows the estimation results of the influence of CGPs on IWM as measured through expenditure on maintenance of water assets (EMWAS) and capital expenditure on new water assets (CENWI). On the same note, the number of females in the management (WOGOS) and water professional and technically skilled employees (WPTSE) are two dimensions that represented corporate governance practices. The total value of assets (TVASS) and population size (POPSZ) as control variables were also incorporated in the regression equations.

Table 4.10 shows results for OLS and FGLS approaches employed to evaluate the impacts of corporate governance practices on IWM in the SAMMs. The results from the two models show that all the regression coefficients are negative, as shown in columns 1- 6, implying that women's participation in management as measured by the WOGOS has had negative effects on EMWAS CENWI and TOIWM.

Table 4. 10: Corporate governance practices and investment in water management

	Ordinary least squares (OLS)			**Feasible generalized least (FGLS)**		
	1	**2**	**3**	**4**	**5**	**6**
	EMWAS	**CENWI**	**TOIWM**	**EMWAS**	**CENWI**	**TOIWM**
WOGOS	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(-0.68)	(-0.95)	(-1.41)
WPTSE	-0.003**	0.001	-0.000	-0.002*	0.001	-0.000
	(0.001)	(0.001)	(0.001)	(-2.28)	(1.03)	(-0.10)
POPSZ	1.178***	0.236	0.764***	-3.420	0.000*	0.000
	(0.288)	(0.277)	(0.223)	(-0.23)	(2.21)	(1.30)
lTVASS	0.106	0.808***	0.504**	1.285***	0.402	0.921***
	(0.295)	(0.283)	(0.228)	(4.81)	(1.54)	(4.37)
_cons	-10.968**	1.714	-5.889	-11.99	8.641	-2.769
	(5.068)	(4.866)	(3.925)	(-1.94)	(1.43)	(-0.57)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

Additionally, the negative effect of WOGOS on IWM turned out to be insignificant, implying that women's involvement in local government affairs has had an immaterial regressive effect on decisions relating to increasing IWM which has a long history of being underfunded. The results contradict the previous studies' results, which found that women's participation in the local municipalities enhanced service delivery performance (Ng'etich, 2015; Araujo & Tejedo-Romero, 2018). However, the negative outcomes might imply that the number of women in the management during the study period was low compared to men. Hence the voices of the few women were not loud enough to influence the IWM decisions in the local municipalities

In the case of WPTSE's influence on IWM, the outcomes were mixed. The relationship between WPSTE as a measure of CGPs and EMWAS turned out to be negative (-0.003** and -0.002*) and significant at 1% and 5% significance levels as displayed in columns 1 and 4, respectively. This suggests that SAMMs tried to address skills shortage problems as a strategy to eliminate repairs and maintenance backlogs, but funding remained a limiting factor (Infrastructure Dialogue, 2015). Concerning the response of CENWI to the influence of WPTSE; a positive and insignificant relationship existed as shown by the regression coefficient of 0.001 and 0.001 under OSL and FGSL, respectively. The results imply that an increase in water experts influenced the local governments' decisions to invest in the acquisition of new water assets to expand the existing SWIF across the municipalities. Similarly, WPTSE negatively influenced total investment in water management (TOIWM) as evidenced by the results shown in columns 3 and 6 (-0.001 and -0.000), meaning that the aggregated expenditures on existing and new assets regressed in response to changes to the numbers of water experts serving in the water departments.

The negative relationship between CGPs and IWM in the SAMMs implies that WOGOS and WPSTE did not have much progressive effect on how WSI were being managed across the SAMMs. In analysing the relationship, it is essential to note the effects of population size (POPSZ) and the total value of assets (TVASS). As shown in Figure 4.10, the control variables have had a positive and significant influence on IWM. However, this suggests that the two control variables were critical in determining the relationship, as confirmed in various studies. According to Gomez *et al.* (2019), an increase in population puts pressure on the government to invest more in essential service delivery. Also, Kleynhans and Coetzee (2019) found that population size determines the quality-of-service delivery in municipalities. On the same note, the TVASS as a measure of municipal size also determines the FP of the firm as earlier alluded to in the literature (Aduda *et al.*, 2013). Ultimately, the negative results demonstrate endless WSDCs in municipalities across the country as postulated in the literature (Makhari, 2016; Masindi & Duncker, 2016; Harding, 2017). Therefore, it is evident that persistent WSDCs might be attributed to the local governments' failure to align CGPs in question with efforts to create stability in the WSI environment.

4.6.2 Examine the relationship between EMPs and IWM

The impact of environmental management practices on IWM in the SAMMs is shown in Table 4.11. The EMPs were measured through expenditure on wastewater management (EOWWM) and expenditure on environmental protection management (EOEPM). The OLS and FGLS results prove that EOEPM has had a negative (-0.034 and -0.132) and insignificant influence on EMWAS as displayed in columns 1 and 4. However, it implies that municipalities might have focused more on building the green infrastructure without addressing weak approaches to repairs and maintenance issues that have contributed to the economic losses resulting from the surge in NREWA.

EOEPM proved to have a positive influence on CENWI as shown by both results of OLS and FGLS that produced positive regression coefficients of 0.088 and 0.005, respectively. The results suggest that municipalities were consistent with the long-standing rhetoric regarding promoting good EMPs to mitigate the climate change effects (Leigh, 2016; Caldecott, 2018). Concerning EOEPM’s relationship with TOIWM (combined EMWAS and CENWI), OLS and FGLS models produced positive and insignificant results. However, the result further confirms the municipalities' position regarding the promotion of good EMPs.

In the nexus between EOWWM and EMWAS, the results were negative (0.141 and -0.0255) using both OLS and FGLS models, as shown in columns 1 and 4, respectively. The EOWWM failed to influence the decision on increasing EMWAS positively. The results suggest that municipalities' wastewater management practices might not have generated adequate income that could have been channelled towards increasing EMWAS to protect the water sources from contamination caused by raw sewage.

Table 4. 11: Environmental management practices and investment in water management

	Ordinary least squares (OLS)			Feasible generalized least square (FGLS)		
	1	2	3	4	5	4
	EMWAS	**CENWI**	**TOIWM**	**EMWAS**	**CENWI**	**TOIWM**
EOEPM	-0.034	0.088	0.076	-0.132	0.005	0.041
	(0.124)	(0.117)	(0.094)	(-1.42)	(0.06)	(-0.57)
EOWWM	-0.141	0.012	-0.046	-0.0255	0.115	-0.101
	(0.095)	(0.090)	(0.072)	(-0.21)	(0.98)	(1.09)
POPSZ	1.176***	0.138	0.656***	-0.001	0.002*	6.81
	(0.280)	(0.264)	(0.213)	(-0.88)	(2.12)	(0.68)
TVASS	-0.153	0.810***	0.387*	1.243***	0.360	0.864***
	(0.276)	(0.261)	(0.211)	(4.64)	(1.37)	(4.14)
_cons	-4.335	2.254	-2.257	-8.232	7.655	-2.373
	(4.009)	(3.793)	(3.058)	(-1.24)	(1.18)	(-0.46)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

For example, failure to address repairs and maintenance challenges resulted in poor wastewater management practices that created a bad situation that led to the contamination of Gauteng's most valuable water source, the Vaal River (Tempelhoff, Munnik & Viljoen, 2007). While the relationship between EOWWM and CENWI turned out to be positive, as shown in columns 2 and 5 (0.012 and 0.115), the positive outcome might have been influenced by the government's conditional transfers that were aimed at developing new water infrastructure. Similarly, the results indicate that more funds were allocated to CENWI than EMWAS, suggesting that the local governments were more concerned with developing new infrastructure than maintaining the existing ones, which has continued to derail efforts towards addressing IWM challenges.

Although the overall results suggest that EMWAS was negatively (-0.046 and -0.101) affected by the EMPs (columns 1 and 6), the CENWI's positive response proved a great deal municipalities manage the climate change-induced risks by expanding SWIF. Notably, the municipalities' endeavours towards increasing expenditure on controlling land and air pollution proved the municipalities' readiness to deal with poor EMPs. The pro-environmental protection actions displayed by SAMMs are imperative to managing risks affecting SWI which are caused by the climate change effects as indicated in the literature (Chinowsky *et al.*, 2015). In addition to applying good EMPs, municipalities must implement measures for dealing with the repairs and maintenance backlog by addressing the EMPs that pose threats to the functionality of SWI in cities.

4.6.3 Evaluate the relationship between social practices and IWM

The results presented in Table 4.12 show the relationship between social practices and IWM in the SAMMs. In this regard, social practices were measured through expenditure on housing opportunities created (EHOCR) and the percentage of households with access to pipe-borne water (PBWAR). Given the OLS and FGLS results shown in columns 1 and 4, the relationship between PBWAR and EMWAS turned out to be negative (-0.015 and -0.0151) and insignificant. The negative effect suggests that municipalities might have been obsessed with the narrative of improving water access rate to gain political mileage and gave less investment attention to the existing repairs and maintenance backlogs.

The negative outcomes are a true reflection of the existing WSDCs that are characterising the big cities in South Africa (Infrastructure Dialogue, 2015; Ruiters & Matji, 2015). However, both OLS and FGLS models' results displayed in columns 2, 3, 5 and 6 indicate that PWAR has had an insignificant positive effect on both CENWI and IWM, thus, suggesting that the increased demand for pipe-borne water caused a major shift in councils' decisions relating to the development of new SWI to reach out to the previously water-deprived communities.

Table 4. 12: Social practices and investment in water management

	Ordinary least squares (OLS)			Feasible generalized least (FGLS)		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	**CENWI**	**TOIWM**	**EMWAS**	**CENWI**	**TOIWM**
PBWAR	-0.015	0.006	0.008	-0.0151	0.00109	0.00482
	(0.019)	(0.018)	(0.015)	(0.81)	(0.06)	(0.33)
EHOCR	-0.120*	0.009	-0.025	-0.118*	0.0220	-0.0159
	(0.061)	(0.059)	(0.047)	(-2.00)	(0.37)	(-0.34)
POPSZ	1.251***	0.145	0.678***	-0.0000	0.0000*	8.598
	(0.282)	(0.270)	(0.218)	(-1.05)	(2.40)	(0.89)
TVASS	-0.133	0.861***	0.434**	1.372***	0.351	0.894***
	(0.268)	(0.257)	(0.207)	(5.02)	(1.29)	(4.12)
_cons	-9.070**	2.419	-3.282	-13.67*	9.477	-2.307
	(4.544)	(4.351)	(3.513)	(-2.07)	(1.45)	(-0.44)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

Concerning EHOCR's impact on investment in repairs and maintenance of water assets (EMWAS), the outcome turned out to be negative and significant at a 10% significant level as shown by the results displayed in column 1(-0.120*) and column 2 (-0.118*). Two of EHOCR coefficients were positive (0.009 and 0.0220) and insignificant for CENWI under both OLS and FGLS models. This might imply that the government, through these municipalities, have made enough provisions in terms of increasing investment in acquiring new SWI assets to match the increasing number of created housing opportunities. The results resonate with Glossop's (2008) results, who established that housing opportunities have had a positive influence on investment in the city of London. However, results indicated in columns 3 and 6 show negative coefficients (-0.025 and -0.0159), suggesting that EHOCR has had regressive impacts on IWM in the metropolitan municipalities.

In light of the neutral results found regarding the relationship between social practices in question and IWM, it shows that the municipalities are still far off from addressing IWM challenges. These challenges inhibit efforts towards eliminating WSDCs in metropolitan cities. However, of great concern was the less attention that was given to the repairs and maintenance of the existing water assets, while more efforts were channelled towards expanding the SWIF. The metropolitan councils have concentrated more on building new water assets than on the expense of repairs and maintenance of existing outdated water infrastructure (Infrastructure Dialogue, 2017). Failure to address repairs and maintenance challenges has led to endless WSDCs in the South African cities (Weaver *et al.*, 2017) and the current challenge relating to the SWI underinvestment gap (Madumo, 2015; Masindi & Duncker, 2016). Therefore, it is fundamental for municipalities to focus on ensuring that the current water investment framework is continuously adjusted in line with the social practices that can directly affect the functionality of WSDSs in cities.

4.6.4 Evaluate the relationship between economic practices and IWM

The results shown in Table 4.13 represent the analysis of the relationship between economic parctices and IWM in the SAMMs.

Economic practices in the municipalities were measured through two main variables directly linked to the municipalities' financial viability, namely non-revenue water (NREWA) and net operating surplus margin (NOSMA).

As shown in Table 4.13, the relationship between NOSMA and EMWAS turned out to be positive but insignificant (0.002) under both OLS and FGLS models. This implies that surplus revenue generated from water activities could have been diverted towards repairs and maintenance, resulting in increased EMWAS. Similarly, CENWI positively and significantly (0.0100^{**}) was influenced by changes in NOSMA, and this suggests the expansion of the SWIF across the SAMMs might have been influenced by the excess revenue generated. However, the combined response of TOIWM to changes in NOSMA turned out to be positive but insignificant, implying that the SAMMs across did not invest much of their revenue in acquiring new water assets

Table 4. 13: Economic practices and investment in water management

	Ordinary least squares (OLS)			**Feasible generalized least (FGLS)**		
	(1)	(2)	(3)	(1)	(2)	(3)
	EMWAS	**CENWI**	**TOIWM**	**EMWAS**	**CENWI**	**TOIWM**
NOSMA	0.002	0.0100**	0.00506	0.002	0.0100**	0.00506
	(0.63)	(2.73)	(1.68)	(0.63)	(2.73)	(1.68)
NREWA	0.0155	-0.00635	-0.00540	0.0155	-0.00635	-0.00540
	(1.26)	(-0.55)	(-0.57)	(1.26)	(-0.55)	(-0.57)
POPSZ	-0.0000	0.0000*	4.96008	-0.0000	0.0000*	4.96008
	(-1.01)	(2.02)	(0.51)	(-1.01)	(2.02)	(0.51)
lTVASS	1.274***	0.476	0.922***	1.274***	0.476	0.922***
	(4.68)	(1.87)	(4.41)	(4.68)	(1.87)	(4.41)
_cons	-12.56*	7.217	-2.579	-12.56*	7.217	-2.579
	(-1.98)	(1.21)	(-0.53)	(-1.98)	(1.21)	(-0.53)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

According to the results, the positive effects of NOSMA, as a measure of FP on IWM, resonates with previous results that found that financial ratios have positively affected drinking water investment (Başci & Başci, 2016). Therefore, it becomes clear that FP has positively influenced IWM in the water department/companies within SAMMs.

Regarding the relationship between non-revenue water (NREWA) and EMWAS, the regression coefficient was positive (0.0155) and insignificant as given in columns 3 and 6, indicating a positive association. This implies that changes to NREWA have had a positive influence on EMWAS across the SAMMs. This also suggests that the municipalities made little effort in addressing repairs and maintenance challenges that have a long-standing backlog (Infrastructure Dialogue, 2015). However, the impact of NREWA on CENWI turned out to be negative (-0.00635 and -0.00635) and insignificant, as shown in columns 2 and 5. Lastly, TOIWM was negatively correlated with NREWA, as evidenced by the negative regression coefficient of -0.00540 shown in columns 3 and 6. Therefore, it is clear that economic losses that arose from the activities relating to the increase in NREWA negatively affected FP in municipalities' constrained efforts to make further investments to acquire new water assets as contended in the literature (Murrar *et al.*, 2017).

The overall results suggest that both the economic factors in question have had a neutral influence on IWM as evidenced by the coefficients for NOMSA and NREMA that showed positive (0.00506) and negative (-0.00540) relationships, respectively. As indicated in the literature, it is quite evident that municipalities struggle to balance their water investment needs due to the high level of NREMA that derailed their capacities to recoup full water costs (Mckenzie, 2014). Furthermore, besides the positive association between NOSMA and TOIWM, the primary concern is the insignificant relationship which implies that not much surplus revenue was invested in water management. Therefore, municipalities should adopt new strategies for increasing IWM by ensuring that NREWA is minimised and the surplus revenue generated is ploughed back into the water department for building and maintaining WSDSs in cities to eradicate prevailing WSDCs.

4.6.5 Examining the overall relationship of SWI factors and IWM in SAMMs

The preceding section presented results that addressed the sub-objectives. The study's main objective was to examine the relationship between SWI factors as represented by SEGE factors and IWM in the SAMMs. Under this section, the study only selected the four most significant variables after performing OLS and FGLS models without control variables (see Appendix, Tables 4.1- 4.4). Table 4.14 presents the estimation results for the impact of SWI factors on IWM in the SAMMs.

Table 4. 14: Evaluating the overall relationship between SEGE factors and IWM.

	(OLS)			(FGLS)		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
Governance	0.00020	-0.00064	-0.00040	0.00020	-0.00064	-0.00040
	(0.44)	(-1.39)	(-1.10)	(0.46)	(-1.45)	(-1.15)
Environmental	-0.0216	0.0894	0.0999	-0.0216	0.0894	0.0999
	(0.17)	(0.72)	(1.01)	(0.18)	(0.75)	(1.05)
Social	-0.108	0.0233	-0.0175	-0.108	0.0233	-0.0175
	(-1.70)	(0.38)	(-0.35)	(-1.77)	(0.39)	(-0.37)
Economic	0.00807	-0.00149	-0.00291	0.00807	-0.00149	-0.00291
	(0.56)	(-0.11)	(-0.26)	(0.58)	(-0.11)	(-0.27)
Control variable	-0.0000	0.0000*	0.00000	-0.0000	0.00000*	0.00000
	(-0.94)	(2.31)	(0.89)	(-0.98)	(2.41)	(0.93)
Control variables	1.328***	0.397	0.914***	1.328***	0.397	0.914***
	(4.67)	(1.43)	(4.12)	(4.86)	(1.49)	(4.30)
_cons	-12.03	6.916	-3.946	-12.03	6.916	-3.946
	(-1.78)	(1.05)	(-0.75)	(-1.85)	(1.09)	(-0.78)
Observations	88	88	88	88	88	88

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Researcher's construct

As shown in Table 4.14, corporate governance practices have positively influenced the EMWAS, as indicated by the regression coefficients shown in columns 1 and 6 (0.00020 and 0.00020). However, the relationship's strength is insignificant, implying that the CGPs did have a slightly positive impact on asset management practices through increasing EMWAS. Despite the positive association, poor asset management practices have continued to derail effective services delivery (SAICE, 2017), and thus point to the fact that more measures need to be put in place to promote the functionality of the SWI. On the same note, the outcomes of the impacts of CGPs on CENWI turned out to be negative and insignificant

Thus, further proving that CGPs failed to enhance investments in the acquisition of new SWI. Despite progress having been made in promoting CGPs, the capacity of the WSAs remain constrained as the SWI underinvestment gap continues to widen, with a growing need to address the existing WSDCs. Overall, the results indicate that a negative and insignificant relationship existed between GCPs and IWM in the SAMMs. However, the negative outcomes are contrary to the various studies that found good CGPs promote better performance in organisations (Cardoso, 2015).

However, negative results are consistent with various views that have been put forward by various authors regarding poor CGPs that have continued to derail the efforts to manage WSI in the South African municipalities. Poor GCPs have been blamed for triggering a series of endless essential service delivery protests which often resulted in social costs through the destruction of the public infrastructure (Morudu, 2017; Ndebele & Lavhelani, 2017). Additionally, the lack of investment in the water sector is also a clear indication of CGPs challenges that have been blamed for discouraging private investors from financial interactions with local municipalities (Makhari, 2016). Besides, the metropolitan government is home to corrupt activities as Mokgopo (2017) postulates that poor CGPs are mostly nepotism, fraudulent activities, and lack of skills. Furthermore, corrupt activities have contributed to incapacitation challenges that have negatively influenced the quality of basic delivery. The poor FMPs are linked to the increasing level of fruitless and unauthorised expenditure as indicated in the Auditor's report on municipalities (Auditor-General South Africa (AG SA), 2019).

Additionally, poor CGPs associated with political influence and poor FMPs (Jacobs, 2019) remain fundamental issues that have developed deep roots in the history of public sector institutions' governance. Considering the complexities involved in managing the local government entities, achieving stability in WSI management remains a mammoth task. Without a paradigm shift in sustainable water management, the prevailing WSDCs associated with an underinvestsment gap remain permanent features in the South African municipalities.

The ultimate results between EMPs and TOIWM turned out to be positive (0.0999) but insignificant. However, of significant concern is the adverse effects of EMPs on repairs and maintenance expenditure, evidenced by the regression coefficient of -0.0216. This implies that less attention in the form of repairs and maintenance was given to the existing infrastructure that transports and distributes water and wastewater. Similarly, the adverse effects of EMPs on EMWAS reflect the truth about infrastructure neglect caused by poor asset management practices. The problems of infrastructure neglect are evidenced by environmentally hazardous wastewater that pollutes land, air and water sources through sewerage pipe leaks and water pipe leaks. For example, contamination in the Vaal River is due to poor wastewater management practices caused by failure to maintain and repair water and wastewater channels (Tempelhoff *et al.,* 2007). CENWI had a positive and insignificant relationship with EMPs. To further explain the relationship, more attention was directed to acquiring new assets at the expense of repairing and maintaining the existing old assets. The relationship's overall positive outcomes resonate with the previous studies that determined that EMPs have had a positive influence on FP (Nyirenda *et al.,* 2013; Maleka *et al.*, 2017; Ali *et al.*, 2019).

Furthermore, the positive results explain the municipalities' position concerning their level of preparedness to implement new measures for building sustainable cities equipped with environmentally friendly SWI. The outcomes are also in line with various studies that have found that good EMPs help reduce the impacts of climate change-induced effects that could lead to less risk exposure to the functionality of SWI (Esterhuyse, 2012; Van den Berg, 2014; Nel & Denoon-Stevens, 2015). Since water utilities are threatened by climate change effects (Koop & Van Leeuwen, 2017), the positive results indicate that the local governments are responding to possible challenges that could arise from climate change effects through building environmentally friendly sustainable infrastructure as recommended in the literature (Bak *et al.,* 2017). Local municipalities must invest in sustainable infrastructure as a defence mechanism against floods and stormy weather to avoid severe infrastructure damages (Grames *et al.,* 2016). The South African government through the DWS has put in place new measures to curb climate change effects by coming up with the Climate Change Response Strategy for the water sector that ensures climate change adaptable SWI is developed in cities (DWS, 2017c). Continued efforts to promote good EMPs in cities are imperative to developing and maintaining SWI to eliminate WSDCs.

Regarding the results in Table 4.14 (column 1), the negative relationship between social practices and EMWAS is shown by the negative regression coefficient (-0.108). The social practices have had a positive but insignificant effect on capital expenditure (CENWI). The overall results suggest that the social practices in question have had a reverse effect on TOIWM, as shown by a negative regression coefficient of -0.018. The results are consistent with Morudu (2017)'s study results that established that social practices constrain the functionality of WSDSs by causing damages that create extra replacement costs. However, social practices failed to stimulate IWM as previously established by various scholars (Glossop, 2008; Zafra-Gómez *et al.*, 2010; Furuoka, 2013; Thuku *et al.*, 2013). The results have developed new impetus for the researcher to discover why the results turned out to be negative.

However, many possible factors could have led to a negative nexus between social practices and IWM. The lack of engagement between the communities and municipal management might have led to the upsurge of violent and destructive protests that caused damages to the SWI resulting in social costs (Ndebele & Lavhelani, 2017; Morudu, 2017). This subsequently resulted in an increased demand for IWM. An increasing number of informal settlements and urban sprawl in the major cities, as indicated in the literature (Ogra & Onatu, 2013), might have increased SWI investment needs. Alternatively, the negative association might be attributed to population increase as indicated in the various studies that found that population density had negatively affected the financial position of the municipalities in South Africa (Kleynhans & Coetzee, 2019; Mahabir, 2010). It has been determined that an unprecedented population increases have negatively affected the water infrastructure's supply capacity (Asoka *et al.*, 2013). Therefore, municipalities must continue to address WSDCs as more attention should be directed towards social factors that negatively influence IWM.

The economic factors have a positive (0.00807) effect on EMWAS, as shown in columns 1 and 4 in Table 4.14. Although the impacts of economic factors were not significant, the positive outcomes show that progressive steps have been taken by the municipalities towards improving financial viability challenges. The results resonate with the previous study's results, which discovered that financial ratios have had positive impacts on drinking water investment (Başci & Başci, 2016). Contrary to the positive connection between EMWAS and economic factors, CENWI and IWM were negatively (-0.00149) and insignificantly influenced by economic practices. The negative relationship proves that the economic practices across the SAMMs have caused a reverse effect on IWM, implying that excessive surplus revenue from water trading activities might not have been used to boost WSI. Therefore, to understand the relationship, it is imperative to gain deep insight into possible factors that might have contributed to the negative results.

Considering the insignificant negative influence of economic practices on IWM, many factors could have played a critical role. The negative association might be attributed to poor revenue collection practices, a poor billing system and poor financial management (Maclean, 2015; Beyers, 2016; Jacobs, 2019). Further, the high level of NREWA estimated to be above 31% in most the municipalities (Mckenzie, 2014; Van den Berg, 2014) might have resulted in substantive economic losses that could have financially constrained municipalities from increasing IWM. Given this point, Yazid *et al. (*2017) ascertained that high levels of NREWA have had regressive effects on the country's finances and the water value chain. Additionally, the water users' attitude towards paying water bills is a significant obstacle towards creating stability in the management of WSI within municipalities. According to Jacobs (2019) results, water users tend not to pay water bills as expected by the municipalities, and hence the cash position of the municipalities and the capacity to provide essential services remain compromised. Therefore, measures need to be put in place to ensure that metropolitan councils improve on poor economic practices that are detrimental to FP and affect the potential to increase water investments to develop and maintain functional WSDSs in cities.

The main objective of the study was to examine the relationship between SWI factors and IWM in the SAMMs. In this case, IWM, as the primary dependent variable, was split into variables, namely EMWAS and CENWI. The overall results were based on the effects of SWI factors, which were put into four categories: social, economic, governance and environmental (SEGE factors), on IWM. Based on the study results presented in Table 4.14, the ultimate results were mixed, with only EMPs having had positive and insignificant effects on IWM. IWM, then again, responded negatively to the influence of social, economic and governance practices. However, considering the results as per objectives, the results are inconclusive, although CGPs have had a purely negative effect on IWM. Proxies of environmental management, economic and social practices produced a neutral relationship. Considering these results, examining the relationship between SWI factors and IWM in the SAMMs turned out to be neutral and inconclusive. Therefore, metropolitan councils must continue putting new measures in place to ensure sanity in WSI environment. To eliminate the prevailing WDSCs in cities, and realise the dreams of developing non-negotiable sustainable cities, stability in water investments management is imperative.

4.7 A FRAMEWORK FOR SUSTAINABLE WATER MANAGEMENT FOR IMPROVED INVESTMENT IN WATER INFRASTRUCTURE

Given the study findings, the framework shown in Figure 4.9 presents an expected paradigm shift in the SWI factors in enhancing the functionality of SWI and management of WSIs for improved WSDSc in cities.

Corporate governance factors

- Capacity-building measures must be put in place, especially in the areas of financial and human resources. There is a need to ensure that employees have adequate skills to avoid skills gap, which can cripple water delivery efforts.
- Political interference in municipalities poses a threat to proper management of water delivery affairs. Hence politicians should not overlap their powers by interfering with the decision made by experts and professionals working in water department.
- The gender gap existing in all levels of management in local government should be addressed by appointing females in management positions.
- Calls for coherence in policy implementation and co-ordinations are relevant in ensuring that SWI factors are well-managed to address WSDCs.
- Accountability and transparency issues are gradually gaining momentum because municipalities need to keep on improving the regulatory framework to promote good governance practices.
- As evidenced by nationwide service delivery protests, all-stakeholder approach involving community forums in decision making concerning water management decisions is pertinent to addressing WSDCs.
- The adherence to NEMA has not been adequately achieved as expected, and as such, financial risk continues to pose a threat to the financial sustainability in municipalities. Hence there is a need to ensure that non-complying municipalities are penalised.

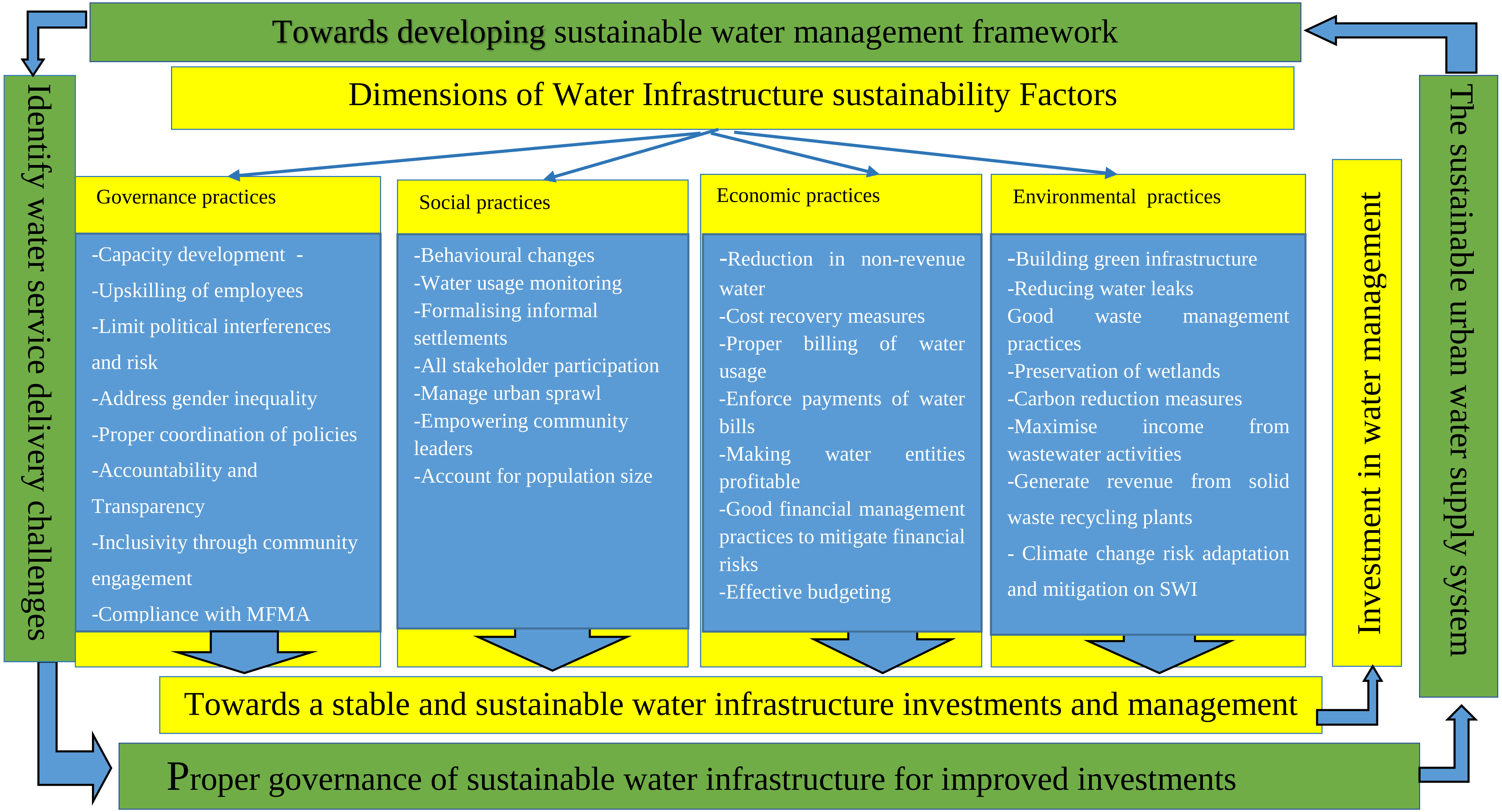

Figure 4. 9 A proposed framework to understand the impacts of SWI factors on investment in water management for effective service delivery system in sustainable cities

Researcher's own construct

Social factors

- The municipalities should encourage water users to be responsible when interacting with SWI components to avoid infrastructure destruction in communities.
- Implementing procedures for water usage monitoring in residential areas is critical for water accounting. This can be done by installing water management devices.
- The municipalities should formalise informal settlements to properly account for the number of households connected to water to achieve effectiveness in managing demand and supply of water services.
- The regulations should be in place to empower community leaders to monitor the functioning of SWI components and also to guard against people who destroy water infrastructure during basic service protests.
- Measures to account for population size should also be put in place by ensuring that urban sprawl is well managed and all residents are well-documented.

Economic factors

- Measures to reduce NREWA should be implemented so that WSAs eliminate economic losses resulting in a lack of funds for investing in water management.
- Given that water utilities are failing to recover water delivery costs, the current water pricing model should be reviewed to allow WSAs to collect enough funds for investment in the water sector.
- The municipalities should invest in new water technology to ensure accurate billing is achieved to avoid water users' disputes.
- Ways of enforcing payments from customers with overdue accounts should be monitored appropriately to avoid bad debts.
- Water entities should be allowed to operate independently without politicians' interference so that economic decisions could be made for improved financial performance.
- The loopholes that allow poor financial management practices should be eliminated and more measures should be put in place to minimise the abuse of public funds.
- Effective budgeting should be enforced in all municipalities, and allocated funds must not be diverted without authorisation to minimise fruitless expenditure.

Environmental factors

- The municipalities must embark on a drive to encourage the development of green infrastructure to mitigate the impacts of climate change effects.
- Measures to manage leaking water and wastewater should be in place in order to keep the environment clean.
- Acceptable waste management practices must be adhered to avoid contamination of the water sources, primarily by ensuring that more than 90% of the wastewater generated is recycled.
- Encouraging water users to preserve natural wetlands as they are essential in natural purification process of wastewater of water.
- Continued efforts aimed at reducing carbon emission should be encouraged and promoted through implementing carbon reduction measures, and this also is done through rewarding complying organisations.
- Ensuring that wastewater processing entities generate enough income for reinvestment.
- Climate change risk adaptability measures are imperative in ensuring that resilient and SWI components are developed to effectively manage climate change-induced risks that threaten the functionality of WSDSs.

4.8 SUMMARY OF THE CHAPTER

The chapter explained in detail the main results of the study. The study presented the univariate analysis results in graphs showing trend analysis and tables providing descriptive data for summary statistics. Bivariate analysis results displayed in tabular format show relationships of paired variables. Based on the results generated from bivariate analysis, almost all the independent variables have positively affected IWM in the SAMMs except NOSMA and PBWAR.

Diagnostic tests such as multicollinearity, heteroscedasticity, serial correlational, and normality ensured the panel data regression models' adequacy. All the regression assumptions were not violated; hence, the regression models performed produced reliable and valid results to address the research inquiry. After considering many factors, the study employed OLS and FGLS approaches to examine the relationship between SWI factors and IMW in the SAMMs. Based on study results at the aggregated level, the relationship between SWI factors and IWM in the SAMMs was mostly inconclusive and insignificant, with only one of four variables having had a positive influence on IWM while the rest were negative. Looking at the results from the disaggregation level (as per individual objective), neutral outcomes were produced as social, environmental, and economic factors have neutral effects on IWM, whereas CGPs managed to influence IWM negatively. Therefore, the relationship between SWI factors and IWM in the SAMMs remains inconclusive. Lastly, the study presented the proposed framework to within which to understand the impact of SWI factors on IWMt for an effective WSDSs in sustainable cities. The next chapter focuses on the discussion of the results, the conclusions reached and the suggested recommendations.

CHAPTER FIVE: DISCUSSION OF RESULTS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

The previous chapter discussed the main results of the study. This chapter presents the following: Section 5.2 discusses results that contribute towards the achievement of the research objectives. Subsequently, Section 5.2.1-5 provides a discussion of the results based on specific research objectives. Section 5.3 provides a discussion on the contributions of the study. Section 5.4 presents recommendations made by the study. Lastly, section 5.5 concludes the study.

5.2 DISCUSSION OF RESULTS TOWARDS THE ACHIEVEMENT OF THE OBEJECTIVES

The main objective of the study provided a theoretical foundation upon which an extensive literature review was done. To understand the relationship between SWI factors and IWM, theoretical perspectives were also incorporated into the discussion. Furthermore, the synthesis of related literature revealed that SEGE factors are fundamental in managing WSI as their influence on drinking water investment remains a bone of contention. According to the literature, it is clear that SEGE factors are multifaceted and can influence the provision of quality water services in many ways. This study pursued a unique approach to address the research objectives by adopting IWM as the primary variable. As the primary variable, IWM is regarded as an instrumental factor that provides a link between the various roles of SWI factors in addressing the existing WSDCs in cities. Owing to the research problem's nature, robust research approaches were followed, including positivism as a philosophical stance, the deductive approach, an archival search, purposive sampling, and quantitative content analysis. The choice of the right measures of SWI factors and IMW was made following the extant literature and in line with the research objectives. Stata and Eviews were used to perform various procedures in analysing the panel data, including conducting bivariate and univariate analysis, diagnostic tests and performing regression models that are part of multivariate analysis. Ultimately, OLS and FGLS were used to examine the relationship between SWI factors and IWM in the SAMMs.

5.2.1 Discussion of Results on Research Objective 1

Determining the relationship between corporate governance practices and investment water management in SAMMs

The study results reveal that CGPs measured through the WOGOS and WPTSE have had a negative and insignificant effect on IWM (see Table 5.10). The negative relationship between CGPs and IWM resonates with various scholars' views about the extent of poor CGPs prevailing in SAMMs (Ruiters & Matji, 2015; Morudu, 2017). Additionally, the existing undesirable water supply situation in the cities is significantly associated with CGPs that promoted inefficiencies in allocating the financial resources resulting in high levels of unauthorized and fruitless expenditures (AG SA, 2019). Furthermore, preventing poor CGPs has become a mammoth task as political interference promotes corruption and cadre deployment in the local municipalities (Mokgopo 2017; Jacobs, 2019). Political interference in the local municipalities is inevitably connected to water services provision. According to White (2015), water is a public good that is a fundamental human right. Water has strategic political importance (Bakker, 2003), which can be used as a tool to gain political mileage. The ongoing basic service delivery protests around the country are mostly triggered by political intolerance that has created a conducive environment for poor CGPs. This often fails to address WSDCs. Therefore, poor CGPs in the local government remain a concerning issue, and this is against the backdrop of not addressing the growing SWI underinvestment gap which has continued to spur WSDCs.

5.2.2 Discussion of Results on Research Objective 2

Key results from examining the relationship between environmental management practices and IWM in SAMMs

The results presented in the preceding chapter (see Table 5.11) depict that the effect of EMPs as represented by EOWWM and EOEPM on IWM turned out to be negative and positive, respectively. However, it is more concerning that both variables in question have had a regressive influence on EMWAS, which further proves maintenance backlogs. On the same note, CENWI was found to be positively correlated with EMPs. The overall outcome based on the relationship between EOWWM and IWM found adverse outcomes, implying that wastewater management practices across the SAMMs spur on IWM as expected. The positive relationship found between EOEPM and IWM resonates with municipalities' preparedness to deal with climate change effects which is a sign of embracing sustainable cities' notion. In addition, the positive link is supported by the results of the previous studies which found that good EMPs mitigate the impact of climate on water provision planning, especially regarding the sustainable water management and IWM (Bak *et al.,* 2017; Koop & Van Leeuwen, 2017; Ali *et al.,* 2019). The overall decision based on this objective suggests that the relationship between EMPs and IWM turned out to be neutral. Therefore, municipalities did not successfully adopt the sustainability imperative, which calls for a balanced approach to dealing with developmental and environmental issues (Radej, 2007) across South Africa.

5.2.3 Discussion of Results on Research Objective 3

Key results from evaluating the relationship between social practices and investment on water managementin SAMMs

The results drawn from the nexus analysis between social practices measured through PBWAR and EHOCR and EMWAS showed adverse outcomes (see Table 5.12). Similarly, PBWAR and EHOCR positively influenced investment in developing new water assets. Thus, implying that more attention was given to the acquisition of new water assets at the expense of repairs and maintenance. However, this continues to draw attention to the existence of WSDCs, which are linked to infrastructure neglect (Infrastructure Dialogue, 2015). Regarding the results, PBWAR has had a positive influence on IWM, further suggesting that local governments have concentrated on establishing new water connections at the expense of resuscitating the water distribution channels. While the negative influence of EHOCR on IWM indicates that not many funds were invested in acquiring new water assets to match the increasing number of housing opportunities across the metropolitan municipalities. Overall, the results show that the relationship between social practices and IWM turned out to be neutral. Relating the results to the concept of infrastructure as a system theory as postulated by Ejigu (2007), it has been established that the SAMMs failed to adopt a balanced approach as EHOCR failed to encourage IWM and thus implying disproportionate attention was given to IWM. Therefore, there is a need to change approaches to addressing WSDCs through ensuring that social practices do not put too much pressure on the functionality of SWI and so further create unnecessary water investment needs in cities.

5.2.4 Discussion of Results on Research Objective 4

Key results from evaluating the relationship between economic factors and investment in water management in SAMMs

An analysis of the relationship between economic factors measured through NOSMA and NREWA and EMWAS produced positive outcomes, implying that the economic practices in question created opportunities that enhanced investments in repairs and maintenance (see Table 5.13). NOSMA has had a positive and significant effect on CEMWI, which further points to the fact that extra income generated might have been used to acquire new water assets. The positive results resonate well with the results of Başci and Başci (2016). Their results acknowledged that FP in municipalities enhanced investment in drinking water. However, NREWA failed to produce a positive influence on the decision to invest in the acquisition of new water assets, implying that a high level of unaccounted water has had a strong link with economic losses that have created challenges for municipalities to increase IWM to cover the SWI underinvestment gap. Overall, the results showed that economic factors have had neutral effects on TOIWM, which resonates well with that fact that water as a basic public good is not supposed to be commodified as this might disadvantage the economically underprivileged water consumers. Therefore, it is critical to continue aligning economic practices, particularly by putting in place relevant measures to reduce NREWA. This could be a mechanism to optimise revenue collection to cater for water investment needs and subsequently eliminate WSDCs in cities.

Overall key results from examining the relationship between sustainable water infrastructure factors and investment in water management in SAMMs

The main results are based on the analysis of the relationship between four (4) SEGE factors (WOGOS, EOEPM, EHOCR and NREWA) and IWM (See Appendices, Tables 5.2-5.5). It has been noted that governance and economic factors have had positive but insignificant effects on EMWAS, while EMPs and social practices induced negative but insignificant impacts on EMWAS (see Table 5.14). However, this implies that not much attention was given to repairs and maintenance; thus, increasing unaccounted water losses and deficiencies in water services provision. The results concerning governance and economic practices showed an insignificant and negative link with CENWI, and additionally, two other variables proved positively and insignificantly correlated with CENWI. The overall results suggest that only EMPs managed to influence IWM positively but insignificantly. Thus, it further proves that investment in new SWI responded positively to increased investment in environmental protection in municipalities. Besides, it proves the readiness of municipalities to address the poor EMPs that can induce climate change risks on SWI, resulting in an increasing demand for funds to invest in water management.

The CGPs social and economic practices' connection with IWM turned out to be negative and insignificant. The negative relationship resonates with various studies supporting the prevalence of poor CGPs (Ruiters & Matji, 2015), poor FMPs (Jacobs, 2019), an increase in unaccounted water (Masindi & Duncker, 2016), and the frequency of service delivery protests which often destroyed infrastructure (Morudu, 2017) and the increase in several informal settlements (Ogra & Onatu, 2013). In summary, the overall results suggest that the relationship between SWI factors and IWM in SAMMs proved to be neutral and insignificant. Therefore, it is upon the municipalities to realise the dream of building sustainable cities by ensuring that all challenges associated with the functionality of SWI factors and IWM are addressed to improve the delivery of water services to better communities in cities.

5.2.5 Discussion of Results on Research Objective 5

Develop a framework for sustainable water management for improved investment in water management in SAMMs

Regarding the results, the researcher proposed a simple framework that water stakeholders should follow to improve effectiveness in managing WSI. Considering that CGPs have had an adverse effect on IWM, municipal councils should consider employing various strategies such as improved transparency and accountability, gender equity, the capacity of human development, and disassociation from political interferences. While in the case of social practices, more needs to be done concerning urban planning to contain urban sprawl, intensify community participation, and promote whistle blowing in reporting poor water usage practices. The economic practices in the areas of the management of NREWA, financial management practices, and cost-recovery measures requires urgent attention to achieve financial sustenance.

Even though EMPs have had a positive effect on IWM, the environmental issues continue to pose a serious threat to the functionality of SWI and the management of WSI in particular. As such, more attention should be given to actions that could help to reduce the impacts of climate change-induced risks by for instance reduction of carbon, building green infrastructure, recycling of both solid waste and wastewater, preserving wetlands, and climate change risk adaptation. Given that guidelines proposed by the framework (Figure 4.9) are strictly adhered to, the researcher is of the view that stability in the water sector is likely to be achieved as municipal councils could balance the water investment needs and government capacity to finance the provision of water services.

5.3 CONTRIBUTION TO THE BODY OF KNOWLEDGE

The study regarding the influence of SWI factors and IWM in SAMMs is regarded as the first in the history of literature on water management as to the researcher's knowledge no other study has utilised a similar research approach to explore ways of addressing WSDCs in the South African context. Given that the study was never done in South Africa, its contributions to the existing literature are entirely engrossing as it opened new ways of pursuing the agenda of addressing WSDCs amid the growing demand for IWM in cities. Therefore, the study results present a new dispensation that is expected to contribute immensely to water investment management by influencing WSAs to consider addressing the influence of SWI factors on IWM as a ground-breaking phase towards addressing long-standing WSDCs. Additionally, another significant contribution of the study concerns the adoption of an empirical approach to establish the effect of the SWI factors on IWM to understand why WSDCs still exist against the backdrop of increased IWM. Therefore, the new approach was undertaken by this study to address WSDCs in the hope of influencing WSAs to not only focus on increasing funding to confront WSDCs, but also to focus on what drives the need for funding. This can serve as a measure for ensuring stability is achieved in the management of WSI in cities.

Several studies have confirmed that WSDCs exist in several places across South Africa (Maclean, 2015; Morudu, 2017; Weaver *et al.*, 2017), while other scholars have acknowledged that financing challenges are blamed for inhibiting the efforts towards expanding the SWIF (Ruiters & Matji, 2015; Masindi & Duncker, 2016). However, this study pursued the debate about building sustainable cities by adopting a new dimension of addressing WSDCs and taking cognisance that the SWI factors directly influence IWM. Therefore, this study brought a new narrative into this field of study by evaluating the extent to which SWI factors can either contribute to achieving stability in the management of WSI or worsen the long-standing SWI underinvestment gap which is blamed for aggravating WSDCs in cities.

The new perspective presented by the study is concerned with ensuring that stability in the management of WSI is achieved by giving attention to economic, social, environmental and governance factors that ensure that unplanned excessive funding needs are contained within the fiscal capacities of the local government's institutions. To be precise, the municipalities should be made aware of the extent to which SEGE factors determine the level of IWM required to gain deep insights into practical solutions to longstanding WSDCs. Given the need to achieve a stable investment-friendly environment in the water sector, the study's contribution is the suggestion that WSAs should not underestimate climate change effects on the functionality of SWI as a strategy to advance the agenda of building more sustainable and resilient infrastructure in transformed cities.

Lastly, in response to the municipalities' slow pace in addressing WSDCs in cities, this study also contributes to the development of a coherent framework for cities' SWI management system, with useful guidelines for dealing with social, environmental, economic, climate change and governance impacts on SWI, which subsequently affect the IWM and water accessibility by the consumers. Figure 4.9 shows a proposed framework ready for implementation by the WSAs to address WSDCs in cities.

5.4 RECOMMENDATION

Based on the OLS and FGSL results, it is clear that only EMPs have had a positive influence on IWM in SAMMs, while social, governance, and economic factors have had an adverse impact. If all the municipalities across the nine (9) provinces instead of only eight (8) SMMAs were part of the study, the results could be different and more robust. Regarding the multivariate regression analysis employed to evaluate the relationship between SWI factors and IWM, the internal validity of the results could be improved if causality analysis and structural equation modeling equations are employed. The employment of quantitative historical data to understand the relationship between SWI factors and IWM might produce robust results if both primary qualitative and quantitative data are included to ensure that community, policymakers and municipal officials provide deep insights into impediments that distract water utilities from providing adequate water services despite increased IWM. Lastly, the researcher did not consider research development and innovation variables in multivariate regression analysis. Hence, the inclusion of the variables is critical to establishing the extent to which new technology could contain SWI challenges that have the potential to increase WSI needs.

5.4.1 Recommendations for Practice and Policy

Based on the study results, the following recommendations are made:

- The government and local municipalities should formulate policies to guide WSAs to manage economic practices that affect the management of NREWA.
- WSPs should install water management devices to assist in managing water usage across all the municipalities.
- In light of violent service delivery protests that destroy SWI across the country, an urgent stakeholder engagement strategy to instill confidence and a sense of responsibility in water consumers is imperative to maintaining existing infrastructure in an adequate state.
- The local government authorities should implement cost-effective approaches to ensure that wastewater recycling generates adequate incomes to financially sustain wastewater recycling operations.
- Policies to improve institutional capacities through skills development programmes are pertinent in ensuring effectiveness and efficiency in providing water services to citizens.
- Policies to empower community forums to have greater involvement in the decisions pertaining to water management issues are imperative to addressing WSDCs.
- The lack of collaboration between national and local authorities concerning water prices continues to cripple water utilities and prevent them from achieving financial sustainability. As such, the researcher recommends the national government and WSAs to formulate water cost models that allow cost-reflective water prices to be charged.

5.4.2 Recommendations for future study

This study examined the relationship between SWI factors and IWM in SAMMs. The fact that only EMPs positvely influenced IWM and the rest of the variables have had negative impacts raises many questions about how sustainability factors can effectively aid the proper management of WSDSs. Based on the newly proposed approaches, further studies in this area are indispensable in addressing IWM challenges and SEGE practices that inhibit efforts towards eliminating WSDCs in cities.

Based on results drawn from historical data, the researcher recommends that further studies in this area employ a mixed methods approach that allows primary data to zoom in on the contemporary issues affecting water utilities in the delivery of water services. On the same note, further studies that incorporate municipalities in both category B and C to understand how SEGE factors influence IWM in small and rural municipalities are needed for generalisation purposes.

Based on the proposed framework to understand the impacts of SWI factors on IWM for effective WSDSs in sustainable cities, future studies should research the operationalisation and contextualisation of the ideas proposed framework (Figure 4.9).

Despite the researcher having succeeded in unearthing a complicated relationship between the SWI factors and IWM, not all avenues were explored to exhaust all proxies of governance, social, environmental, and economic practices. Therefore, further studies are recommended to delimit the approaches of addressing WSDCs by considering other SEGE measures that tend to have effect on IWM as an avenue of broadening the debate. Similarly, future studies are expected to investigate measures for saving water and reducing NREWA water particularly in other areas where treated water instead of raw water is used for irrigation purposes in residential locations.

Additionally, the researcher established that WSAs provide free water to non-indigents. This implies that the existing high levels of NREWA in municipalities could be addressed if future studies could focus on economic losses arising out of the failure by local government to account for the number of deserving beneficiaries of free water and sanitation services.

Lastly, proposed future studies should consider testing the proposed framework to establish its effectiveness and any weaknesses to propose recommendations for improvement.

5.5 CONCLUSION

The study results established that only EMPs have had a positive and insignificant impact on IWM; while results on the relationship between social governance and economic practices and IWM produced adverse outcomes. The results instead suggest that SAMMs failed to prioritise sustainability practices that promoted stability in WSI management to ensure that WSDCs are eradicated. Given the results, it is apparent that the sustainability imperative which focuses on balancing the attention given to dimensions of capital such as economic, human, natural and social capital (Radej, 2007) was not fully adopted as only EMPs have had a positive influence on IWM. The rest of the variables that produced negative relationships with IWM proved that disproportionate attention was given to all capital pillars in municipalities.

Furthermore, the theory of public good is crucial in justifying the study results. Water as a basic human need, which according to the CRSA (1996), should be provided for free to the people who cannot afford it. The negative impacts of economic factors on IWM confirm that it is the highly subsidised water prices that make it difficult for WSPs to recover full water costs. In other words, indigents are accessing free water. This implies that the NREWA represents economic losses that are absorbed by the municipalities while at the same time, they are failing to address the SWI underinvestment gap. Similarly, the prevalence of water leaks and burst water pipes has increased NREWA, signifying the municipalities' failure to fully embrace the infrastructure as a system theory that advocates for infrastructure as a network of interconnected elements. The failure by municipalities to address repairs and maintenance challenges has resulted in infrastructure system failure, hence suggesting that the negative impacts caused by social, economic and governance factors can be attributed to a lack of congruence with the theory of infrastructure a system.

Considering the study results, this study provided an opportunity for municipalities to reconfigure their water services delivery and strategic plans to manage water investments by ensuring that sustainability dimensions receive equal attention. To ensure that WSDCs are eliminated in cities, the study made a modest contribution to the extant literature by closing an existing knowledge gap as to my knowledge no empirical study has taken a similar approach in the context of SAMMs to investigate the same matter. Additionally, the study's significant contribution relates to the proposed framework to understand the impacts of SWI factors on IWM for effective WSDSs in sustainable cities. The framework is a roadmap towards developing sustainable cities (focusing on SGDs 6 and 11) equipped with innovative water technology infrastructure that is environmentally friendly and resilient. Therefore, it is fundamental to implement measures for improving WSDSs as sustainable cities' development narrative continues to gain traction around the world.

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Appendix A: Definition of terms

Corporate governance is a system that involves collecting processes and mechanisms used by the organisations to direct and control their business objectives (L'Huillier, 2014).

Environmental management factors are measures put in place by any organisation aimed at mitigating the impacts caused by business activities on the environment and its inhabitants (Sroufe, Montabon, Narasimhan & Wang, 2002).

Infrastructure sustainability: refers to the situation where dimensions of all sustainable development dimensions must be met, including social, economic, institutional and environmental (Corfee-Morlot, 2016).

Infrastructure: refers to all forms of structure that enable the provision of services and facilities needed for the proper functioning of an economy and society's functioning (Ruiters, 2011).

Investment in water management refers to capital expenditure invested in new and existing infrastructure, while operating expenditure is mainly bulk purchases (RSADNT, 2019).

Metropolitan municipalities refer to the category that executes all local government functions for a city or conurbation. The metropolitan municipalities are characterised by cities and towns and usually command economic and social influence (Thwala & Aigbavboa, 2013).

Sustainability: refers to any actions focusing on providing equality to economic, social and environmental domains without compromising the future generation's needs (Alhaddi (2015).

Sustainable cities refer to ***cities*** designed to fulfil the current needs without compromising future needs, and the notion stresses balancing the needs of the environment, society and economy (Lundqvist, 2007).

S**ustainable development:** is **the development** that meets the needs of the present without compromising the ability of future generations to meet their own needs (Robert, Parris & Leiserowitz, 2005).

Sustainable water infrastructure refers to infrastructure components that meet the required sustainability standard and ensure that the quality of sustainable development ensures that adequate and quality water services are continuously supplied without compromising water security (Heare, 2007).

Water infrastructure refers to the vast numbers of groundwater wells, surface-**water** intakes, dams, reservoirs, storage tanks, drinking-**water** facilities, pipes, and aqueducts (Heare, 2007).

Water security: refers to the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks (Cook & Bakker, 2012).

Water service delivery challenges refer to the factors that inhibit the proper delivery of water services in this study's context (Weaver *et al.,* 2017).

Water: the clear liquid with no colour, taste, or smell, that falls from clouds as rain that forms streams, lakes, and seas, and that is used for drinking, washing (Merriam-Webster, 2020).

Appendix B: Research Data on Variables

Table 3.1: Dependents variables representing investment in water management

MucipalCode	Year	Expenditure on maintenance of water assets	Capital expenditure on new water infrastructure	Total investment in management
municipalCode	year	EMWAS	CENWI	TOIWM
1	2009	124052310	48279620	172331930
1	2010	162342000	54611748	216953748
1	2011	262002232	74797299	336799531
1	2012	263802442	74797299	535883442
1	2013	133550546	74797299	357032542
1	2014	133379926	74797299	389823653
1	2015	85077713	74797299	421941965
1	2016	116998044	74797299	395350373
1	2017	217378588	74797299	424898768
1	2018	412579000	74797299	777743279
1	2019	341772000	74797299	1038076000
2	2009	167731431	74797299	793697770
2	2010	22526350	74797299	405408587
2	2011	17112552	74797299	364294181
2	2012	133620953	74797299	445237678
2	2013	106039966	74797299	566484633
2	2014	54602984	74797299	537773116
2	2015	84067442	74797299	393323364
2	2016	152795507	74797299	623126633
2	2017	184445968	74797299	656906017
2	2018	16498164	74797299	176138701
2	2019	38000000	74797299	411655000
3	2009	29500000	74797299	1154467970

3	2010	671277000	74797299	2344385939
3	2011	396483000	74797299	1475598301
3	2012	396483000	74797299	473883000
3	2013	479456219	74797299	1044214889
3	2014	548329476	74797299	1200305476
3	2015	594529510	74797299	1397521510
3	2016	677486890	74797299	1218876890
3	2017	51756600	74797299	802732600
3	2018	589421000	74797299	1062330398
3	2019	450000000	74797299	983000000
4	2009	84600000	74797299	299639764
4	2010	56481582	74797299	141546568
4	2011	22543817	74797299	162281626
4	2012	23977669	74797299	203281326
4	2013	50475532	74797299	314931485
4	2014	63916115	74797299	445686897
4	2015	413630409	74797299	856549240
4	2016	455983056	74797299	1001136424
4	2017	74195872	74797299	687427616
4	2018	99625341	74797299	1020847848
4	2019	125054810	74797299	1998118810
5	2009	97583850	74797299	312597285
5	2010	108781670	74797299	324194046
5	2011	119414735	74797299	264601821
5	2012	107789663	74797299	479463352
5	2013	126349201	74797299	387786272
5	2014	106757754	74797299	287352081
5	2015	150099764	74797299	325901876
5	2016	79118563	74797299	261707440
5	2017	96398032	74797299	286207058
5	2018	43956028	74797299	284827051

5	2019	114596000	74797299	459256000
6	2009	17470000	74797299	79189746
6	2010	19340000	74797299	88546351
6	2011	18696377	74797299	83977653
6	2012	37048945	74797299	99662365
6	2013	26976122	74797299	79714740
6	2014	30865839	74797299	99628957
6	2015	34411560	74797299	125163626
6	2016	41907386	74797299	49382032
6	2017	46388480	74797299	224413271
6	2018	50843637	74797299	182892246
6	2019	37097000	74797299	219675000
7	2009	15386324	74797299	23021213
7	2010	14523615	74797299	24330742
7	2011	12358155	74797299	21952582
7	2012	15639209	74797299	95470693
7	2013	123341000	74797299	280529253
7	2014	131992000	74797299	286840765
7	2015	78517392	74797299	432459911
7	2016	149401315	74797299	344892621
7	2017	121731614	74797299	155123521
7	2018	148212504	74797299	175511923
7	2019	120380513	74797299	244943513
8	2009	77900000	74797299	576070000
8	2010	91200000	74797299	403713000
8	2011	97280000	74797299	770086000
8	2012	225581000	74797299	765212594
8	2013	333153000	74797299	1095385269
8	2014	293134000	74797299	1313416765
8	2015	408399000	74797299	817192000
8	2016	101010000	74797299	596167000

8	2017	452484000	74797299	837767000
8	2018	421679000	74797299	630856000
8	2019	120000000	74797299	300000000

Source: Reasecrher's construct

Table 3.2: EHOCR, PBWAR,EOWWM and EOEPM (Indepenendent variables)

MucipalCode	Year	expenditure on housing opportunities created	Percentage: Pipe borne water access rate	Expenditure on waste water managment	Expenditure on envrionmental protection management
	year	EHOCR	PBWAR	EOWWM	EOEPM
1	2009	261106826	93.2	170161233	8644998
1	2010	283624592	93.5	163890210	123285979
1	2011	189563439	93.2	170807614	119338120
1	2012	86615461	98	395584753	54481934
1	2013	44372453	99	437804158	55162245
1	2014	56869366	99	430460816	38262329
1	2015	138432022	100	509712226	65888749
1	2016	15608950	100	624688980	75661382
1	2017	177804475	97	579479844	97053159
1	2018	1396706021	95.5	755712441	90845256
1	2019	298709000	98	705584000	61033000
2	2009	264396373	98.6	200863122	40139551
2	2010	30200000	99.6	286828565	45388485
2	2011	150312111	89.2	307912909	51179151
2	2012	350000000	100	375624219	55891318
2	2013	546000000	90	408888961	42081037
2	2014	453000000	85	587234117	216618151
2	2015	369354274	81.05	725672969	140277492
2	2016	32280719	82.24	518705114	32004784

2	2017	38913489	82.2	548132543	29985887
2	2018	641514827	82.2	614512217	145362154
2	2019	538580000	86	829563000	51500000
3	2009	95600000	95.9	54651278	220347217
3	2010	5890000	96	111101366	102631534
3	2011	5966200	92.2	110223631	102760150
3	2012	6100000	92.25	109994075	117597481
3	2013	6721717	87.75	119506013	121643737
3	2014	6370152	88.17	12836966	136645663
3	2015	12420322	92.75	139912623	150314951
3	2016	130000000	90	152096960	124305869
3	2017	130000000	91.81	170091909	139632037
3	2018	55996000	96.75	186040757	218531208
3	2019	458100000	84.66	172243700	228659207
4	2009	15587770	100	509906927	145830751
4	2010	59119004	100	654387119	166637679
4	2011	85438310	96.6	787280039	193787672
4	2012	345109546	96.6	861288864	193721843
4	2013	371113668	97.8	992321029	232978542
4	2014	871262082	98.8	1081164127	90347833
4	2015	962099000	98.9	1183620336	108322464
4	2016	413027809	99	1430411263	113936634
4	2017	1343676621	99.8	1393122458	113416863
4	2018	274586962	99.24	1111255975	125801713
4	2019	261564000	99.8	1291050000	138186563
5	2009	145109870	100	226408447	53931228
5	2010	151870710	100	261768828	86189864
5	2011	160675370	100	344018441	91118236
5	2012	3350311	100	296060706	239175754
5	2013	146109001	100	335235024	265024222
5	2014	420623000	100	316353348	115315765

5	2015	201395465	100	376926336	133236037
5	2016	236426725	100	411728570	150547267
5	2017	220061067	100	457088228	37516863
5	2018	220839153	98	491509814	38893476
5	2019	178549000	97.8	519958542	39889630
6	2009	2456289	97.4	181260088	64100924
6	2010	2623983	97.8	213821454	66738639
6	2011	7113000	98	191717581	71952226
6	2012	14023000	95	180849833	76997524
6	2013	43898000	100	178014092	80811987
6	2014	42513869	98	239917092	95614572
6	2015	144793000	99	229520412	99210004
6	2016	42513869	99.4	378260078	107629270
6	2017	184941458	98.2	326507893	121351704
6	2018	131123316	97.7	303304887	23069203
6	2019	170502000	98	314182000	124563236
7	2009	327401	92.2	79865235	12058950
7	2010	17037116	93	88405951	14251049
7	2011	5395414	93.02	93805763	12531905
7	2012	8894380	95.19	130995093	17812383
7	2013	5459263	94.54	148669228	14063249
7	2014	8500000	95	2178740503	16428835
7	2015	19264063	95	142933126	17910386
7	2016	49420514	98.1	266349529	22633202
7	2017	13942148	95	229213178	23151818
7	2018	29673000	90	391009461	24324378
7	2019	10396000	99.4	441204000	24769658
8	2009	569499000	96	1636673000	43022000
8	2010	401564000	97.42	1085000000	583015000
8	2011	274861000	97.42	1934685000	56680000
8	2012	156623000	91.23	2161464800	88416000

8	2013	159556820	91.23	2426570600	79784000
8	2014	1364287750	91.67	2677573203	178572711
8	2015	493403000	94.01	28804000	183230499
8	2016	463981000	96.15	288404000	183230499
8	2017	277240000	97.89	3283176144	179700000
8	2018	835914000	98.5	3519843529	156798987
8	2019	1072376234	99.1	369572056	128737695

Source: Reasecrher's construct

Table 3.3: WOGOS, WPSTE, NSOMA and NREWA (Independent Variables)

MucipalCode	Year	women in managerial positions and councellors	Water professionals and techncally skilled employees	Percentage: Net surplus operating margin	Pecentage: Non revenue water
municipalCode	year	WOGOS	WPTSE	NOSRE	NREWA
1	2009	290	122	-28.70	28.5
1	2010	310	124	-27.14	29.2
1	2011	320	135	-7.47	29.62
1	2012	302	153	24.50	30.34
1	2013	362	159	16.38	39.7
1	2014	310	171	18.73	37.7
1	2015	350	198	25.15	36.1
1	2016	340	171	19.89	34.6
1	2017	359	175	10.40	30.57
1	2018	801	241	2.00	28.45
1	2019	801	125	13.99	29.93
2	2009	77	180	22.62	27.6
2	2010	173	235	12.77	26.6
2	2011	160	235	22.23	28.64
2	2012	234	250	13.83	24.7

2	2013	357	282	18.34	24
2	2014	439	282	14.13	23.55
2	2015	465	315	16.52	23.03
2	2016	485	433	19.42	23.83
2	2017	453	535	19.74	27.8
2	2018	440	436	42.68	27.9
2	2019	431	286	29.05	32.9
3	2009	245	153	-2.79	36.4
3	2010	254	155	11.40	33
3	2011	274	157	13.45	33.2
3	2012	272	130	4.33	37.7
3	2013	284	146	-2.68	39.4
3	2014	285	146	-15.79	39.2
3	2015	432	146	6.44	36.2
3	2016	546	148	-6.09	40.66
3	2017	633	155	-3.22	35.52
3	2018	663	162	-2.39	32.7
3	2019	649	170	0.08	33.4
4	2009	102	315	-6.44	23.2
4	2010	108	315	10.94	25.3
4	2011	106	318	2.11	23.3
4	2012	111	322	8.43	20.5
4	2013	107	320	7.55	20.8
4	2014	117	320	14.67	36.2
4	2015	117	349	46.43	40.66
4	2016	126	530	59.61	11.65
4	2017	199	438	50.04	12.26
4	2018	203	484	12.02	14.82
4	2019	212	545	42.57	16.52
5	2009	52	132	35.24	25.8
5	2010	54	130	25.34	37.8

5	2011	63	143	22.04	40.2
5	2012	68	144	6.22	36
5	2013	78	148	50.32	41.9
5	2014	92	111	67.32	42.3
5	2015	104	121	49.27	41.9
5	2016	90	134	49.60	43.5
5	2017	90	128	40.69	35.5
5	2018	100	129	43.04	41.1
5	2019	131	139	71.07	43.9
6	2009	53	85	-4.84	41.8
6	2010	68	89	6.21	40
6	2011	67	92	-37.88	47
6	2012	61	62	-19.29	45
6	2013	68	96	3.67	38
6	2014	67	106	-1.27	38
6	2015	72	106	-24.47	41
6	2016	74	112	-13.97	40.98
6	2017	75	110	-3.16	40
6	2018	75	109	1.52	43.69
6	2019	77	120	1.51	46.11
7	2009	39	43	41.12	52.2
7	2010	39	45	28.52	50.3
7	2011	41	48	32.77	35.9
7	2012	42	48	31.93	43.3
7	2013	40	49	4.63	30.3
7	2014	45	55	4.76	31
7	2015	41	121	6.86	45
7	2016	42	165	-25.46	41
7	2017	52	123	1.79	35.2
7	2018	55	125	-30.04	35.2
7	2019	57	120	-11.81	34

8	2009	1256	140	3.78	36.15
8	2010	578	143	1.07	37.4
8	2011	534	143	-56.40	38.5
8	2012	522	144	13.54	30.3
8	2013	490	155	18.66	38.9
8	2014	924	145	13.69	35
8	2015	955	157	7.53	35.8
8	2016	1100	163	11.59	35.3
8	2017	1401	148	0.73	40.3
8	2018	1410	154	12.17	32
8	2019	1378	154	7.34	38.6

Source: Reasecrher's construct

Table 3.4: TVASS and POPSZ (control variables)

MucipalCode	Year	Total value assets	COJ SA District population projections
municipalCode	year	TVASS	POPSZ
1	2009	49948177730	2844706
1	2010	49512997428	2873997
1	2011	47365219794	2800000
1	2012	49793042794	2999000
1	2013	52923531407	3178470
1	2014	54894100332	3237851
1	2015	60576976078	3310336
1	2016	63448249803	3485697
1	2017	63395609231	3461437
1	2018	69636964497	3528800
1	2019	73243980000	3594636

2	2009	17969720840	2640000
2	2010	19010145046	2740000
2	2011	21637478536	2830000
2	2012	26047867985	2920000
2	2013	29934801987	3010000
2	2014	35647341414	3090000
2	2015	38214135643	3161809
2	2016	43235195532	3230000
2	2017	48533767234	3310000
2	2018	51552011928	3322000
2	2019	55890756000	3410000
3	2009	34297153000	3552702
3	2010	38869243000	3584681
3	2011	42609538000	3442361
3	2012	46380427000	3446447
3	2013	48933836000	3480726
3	2014	52987242000	3517157
3	2015	55395523000	3555868
3	2016	60139131000	3596543
3	2017	62616691000	3638918
3	2018	64599397000	3682524
3	2019	70819448000	3727032
4	2009	24095037000	3497097
4	2010	28938515000	3598000
4	2011	31338150000	3700000
4	2012	35508522601	3789900
4	2013	41934642033	3805000
4	2014	45138512992	3918830
4	2015	49769188153	3998000
4	2016	54560345040	4004793
4	2017	58667208398	4174510

4	2018	65108329614	4259828
4	2019	70953563000	4345143
5	2009	11669616191	1099860
5	2010	13409671701	1125635
5	2011	13409671701	1152112
5	2012	14938157836	1100000
5	2013	15829877866	1152115
5	2014	16649952558	1152115
5	2015	17291222381	1224630
5	2016	18296669217	1256385
5	2017	19751579480	1270000
5	2018	22383156617	1230000
5	2019	23919400000	1270000
6	2009	13542839874	711005
6	2010	12795928522	722985
6	2011	13086951443	735922
6	2012	12756305000	766482
6	2013	13049871000	775872
6	2014	15294300505	777872
6	2015	16076738125	789454
6	2016	17299570068	801217
6	2017	19263763423	834018
6	2018	22050918654	851368
6	2019	23850307888	868718
7	2009	3485555034	711005
7	2010	4878141787	722985
7	2011	11686739754	735922
7	2012	12406859925	725245
7	2013	13509273782	735800
7	2014	15013782494	747431
7	2015	17528244636	787929

7	2016	18974376878	787930
7	2017	21006147726	784490
7	2018	21619303818	896938
7	2019	21929562232	899692
8	2009	39885064000	4116290
8	2010	42930190000	4260564
8	2011	47439904000	4411658
8	2012	56357268000	4564124
8	2013	61131726000	4719480
8	2014	66924485000	4878057
8	2015	77526300000	5039363
8	2016	80377779000	5203338
8	2017	82327358000	5367688
8	2018	85183946000	5538044
8	2019	95436627300	5688521

Source: Reseascher’s construct

Appendix C: Ordinary least squares and Feasible generalized least squares results

Table 4.1: Determine the relationship between corporate governance practices and investment water management (IWM)

	OLS			FGLS		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
WOGOS	0.00137***	0.00115***	0.00125***	0.00137***	0.00115***	0.00125***
	(4.39)	(4.05)	(4.91)	(4.47)	(4.12)	(5.00)
WPTSE	0.000623	0.00387***	0.00307***	0.000623	0.00387***	0.00307***
	(0.69)	(4.70)	(4.14)	(0.70)	(4.79)	(4.21)
_cons	17.90***	18.18***	18.75***	17.90***	18.18***	18.75***
	(83.50)	(93.23)	(106.82)	(84.96)	(94.86)	(108.69)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Reasecrher's construct

Table 4.2: Examine the relationship between environmental management practices and IWM

	OLS			FGLS		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
EOWWM	0.0523	0.196	0.154	0.0523	0.196	0.154
	(0.48)	(1.93)	(1.68)	(0.48)	(1.96)	(1.71)
EOEPM	0.303*	0.448***	0.446***	0.303*	0.448***	0.446***
	(2.27)	(3.62)	(4.00)	(2.31)	(3.69)	(4.07)

_cons	11.90***	7.246*	8.557***	11.90***	7.246**	8.557***
	(4.00)	(2.62)	(3.44)	(4.07)	(2.67)	(3.50)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Reasecrher's construct

Table 4.3: Evaluate the relationship between social practices and IWM

	OLS			FGLS		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
PBWAR	-0.0220	-0.0296	-0.0304	-0.0220	-0.0296	-0.0304
	(-0.95)	(-1.37)	(-1.56)	(-0.97)	(-1.39)	(-1.58)
EHOCR	0.117	0.223***	0.211***	0.117	0.223***	0.211***
	(1.85)	(3.77)	(3.95)	(1.88)	(3.84)	(4.02)
_cons	18.39***	17.99***	18.75***	18.39***	17.99***	18.75***
	(7.52)	(7.85)	(9.07)	(7.65)	(7.99)	(9.23)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Reasecrher's construct

Table 4.4: Evaluate the relationship between economic factors and IWM

	OLS			FGLS		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
NOSMA	-0.00223	0.00698	0.00103	-0.00223	0.00698	0.00103
	(-0.45)	(1.51)	(0.24)	(-0.46)	(1.54)	(0.25)
NREWA	-0.0211	-0.0450***	-0.0443***	-0.0211	-0.0450***	-0.0443***
	(-1.51)	(-3.49)	(-3.74)	(-1.54)	(-3.55)	(-3.81)
_cons	19.18***	20.71***	21.21***	19.18***	20.71***	21.21***
	(38.40)	(44.75)	(49.99)	(39.07)	(45.53)	(50.86)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Reasecrher's construct

Table 4.5: Examining the overall relationship between sustainable water infrastructure factors and investment in water management

	OLS			FGLS		
	(1)	(2)	(3)	(4)	(5)	(6)
	EMWAS	CENWI	TOIWM	EMWAS	CENWI	TOIWM
WOGOS	-0.0000	-0.000	-0.000376	-0.00000	-0.0003	-0.000376
	(-0.01)	(-0.76)	(-0.90)	(-0.01)	(-0.82)	(-0.96)
WPTSE	-0.00268	0.000493	-0.000632	-0.00268	0.000493	-0.000632
	(-1.82)	(0.34)	(-0.54)	(-1.94)	(0.37)	(-0.58)
EOWWM	-0.0423	-0.0388	-0.0448	-0.0423	-0.0388	-0.0448
	(-0.37)	(-0.35)	(-0.50)	(-0.40)	(-0.38)	(-0.53)
EOEPM	0.0226	0.105	0.106	0.0226	0.105	0.106
	(0.18)	(0.84)	(1.04)	(0.19)	(0.90)	(1.12)
PBWAR	0.00665	-0.00224	-0.000826	0.00665	-0.00224	-0.000826
	(0.31)	(-0.11)	(-0.05)	(0.33)	(-0.12)	(-0.05)
EHOCR	-0.111	-0.0183	-0.0300	-0.111	-0.0183	-0.0300
	(-1.56)	(-0.26)	(-0.53)	(-1.67)	(-0.28)	(-0.57)
NOSMA	0.00774	0.00977*	0.00634	0.00774	0.00977*	0.00634
	(1.76)	(2.28)	(1.82)	(1.88)	(2.44)	(1.94)
NREWA	-0.0120	0.00148	-0.00816	-0.0120	0.00148	-0.00816
	(-0.69)	(0.09)	(-0.60)	(-0.74)	(0.09)	(-0.64)
POPSZ	-9.2900	0.0000	9.788	-9.29e-08	0.00000	9.788
	(-0.58)	(1.79)	(0.77)	(-0.62)	(1.91)	(0.83)
TVASS	1.455***	0.519	0.996***	1.455***	0.519*	0.996***
	(5.02)	(1.84)	(4.34)	(5.37)	(1.97)	(4.63)
_cons	-13.85	5.228	-4.607	-13.85*	5.228	-4.607
	(-1.88)	(0.73)	(-0.79)	(-2.01)	(0.78)	(-0.84)
N	88	88	88	88	88	88

t statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Reasecrher's construct

Appendix D: Graphical display of the relationship between SWI factors and IWM

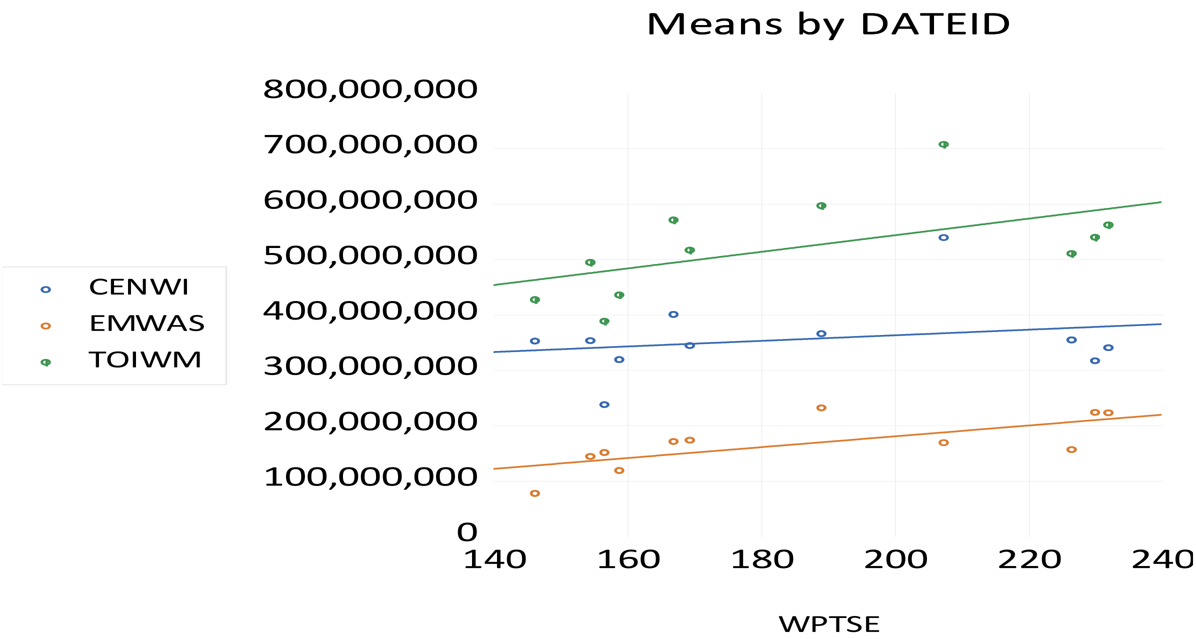

Figure 4.1: The relationship WPTSE and TOIWM

Source : Researcher's construct

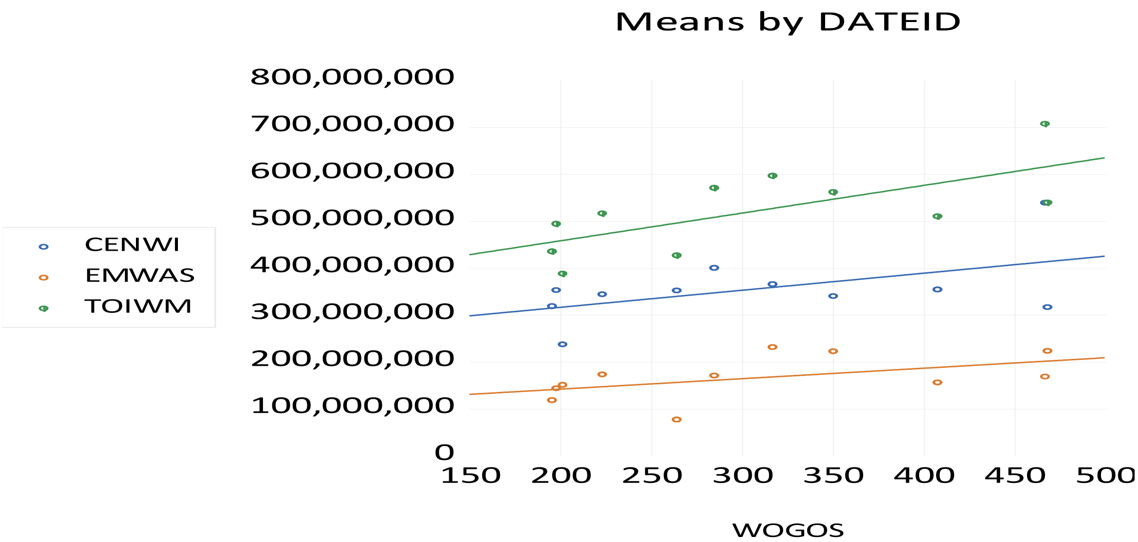

Figure 4.2: The correlation between WOGOS and TOIWM

Source: Researcher's construct

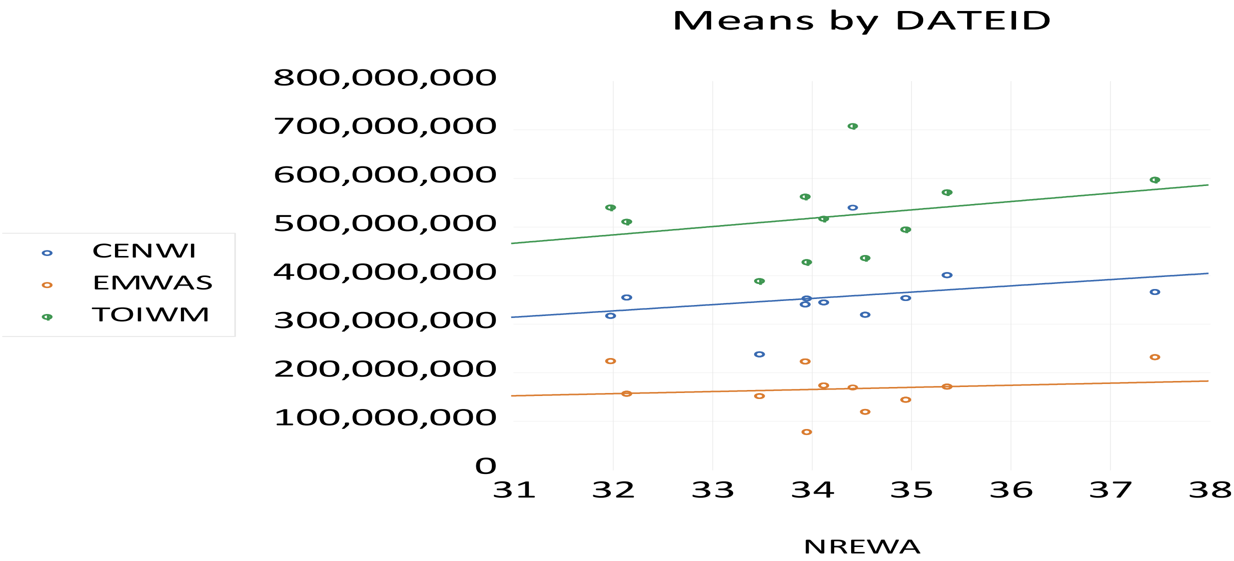

Figure 4.3: correlation between NREWA and TOIWM

Source: Reasecrher's construct

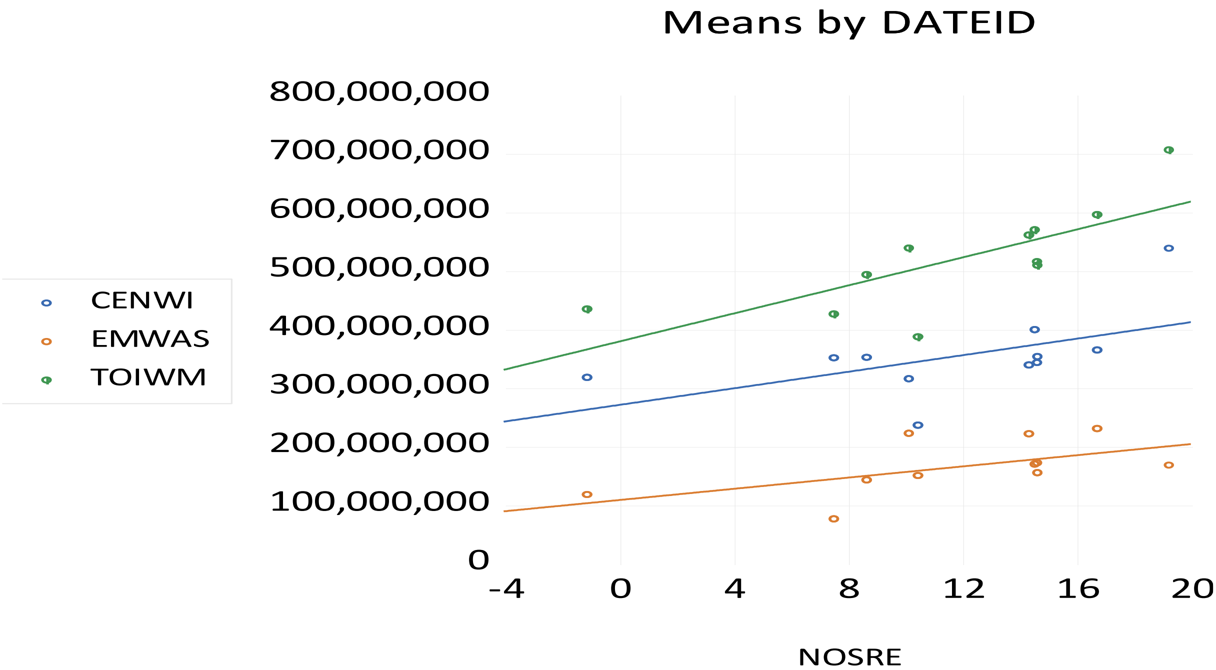

Figure 4.4: Correlation between NOSMA and TOIWM

Source : Researcher's construct

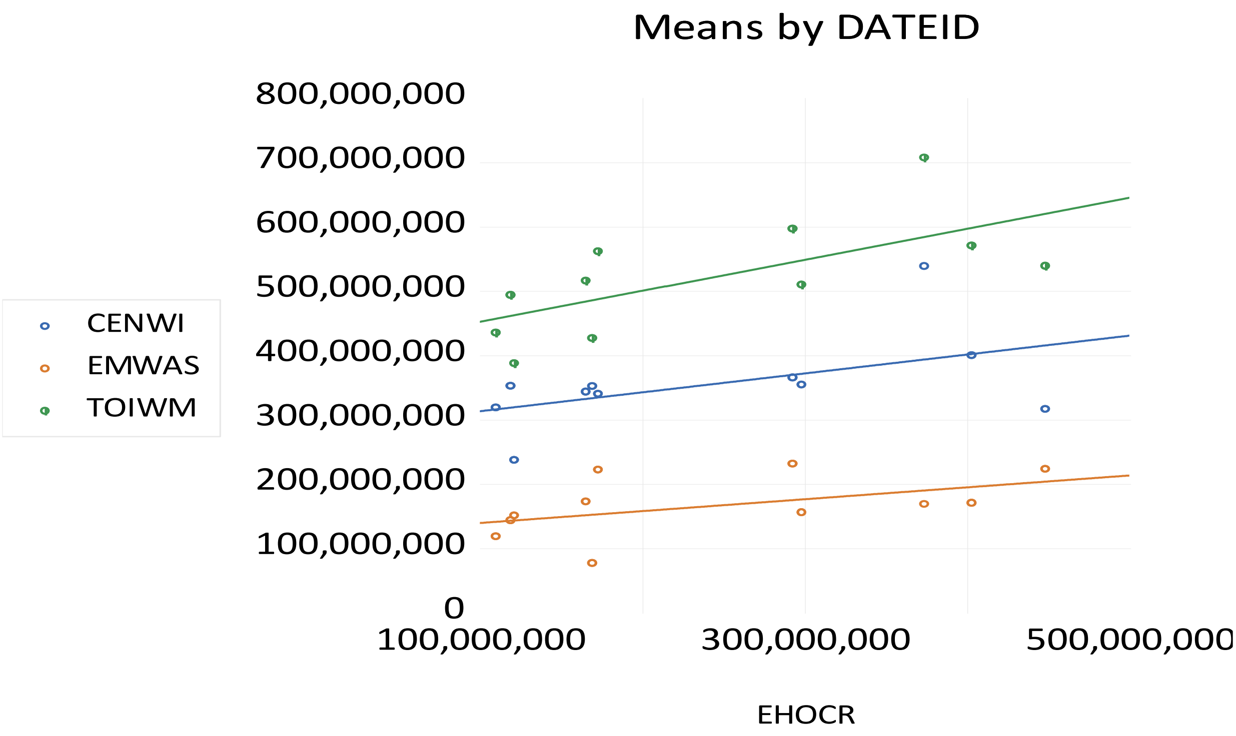

Figure 4.5: correlation between EHOCR and TOIWM

Source: Researcher's construct

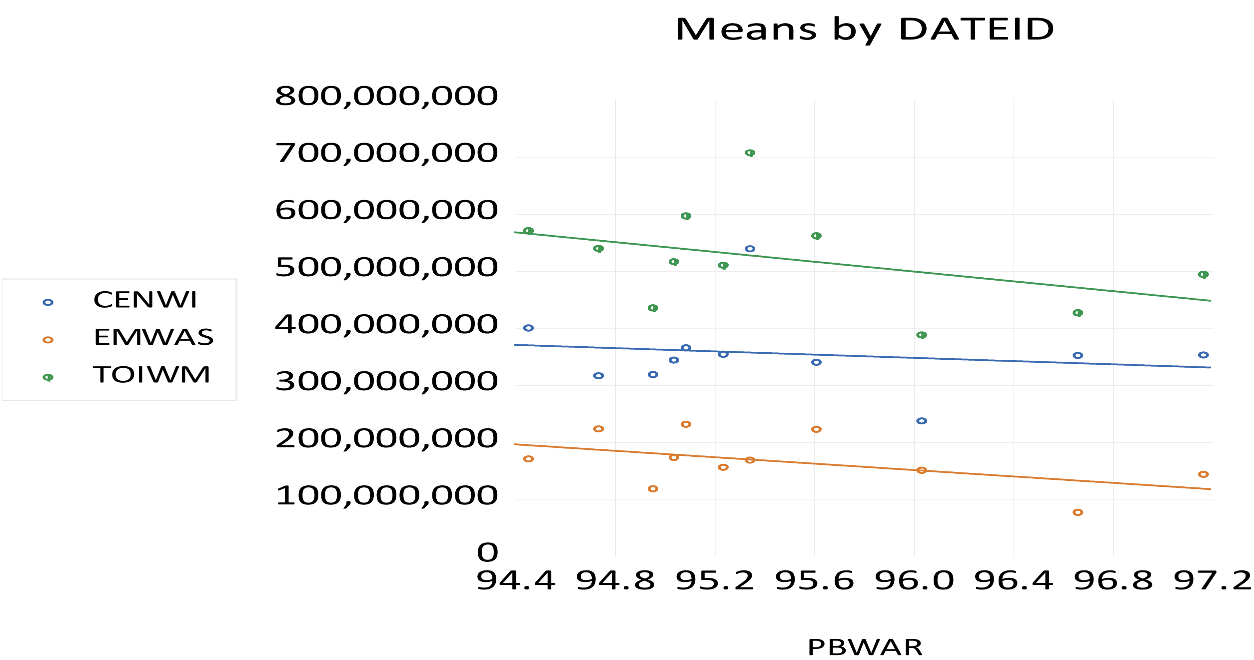

Figure 4.6: Correlation between PBWAR and TOIWM

Source: Researchers' construct

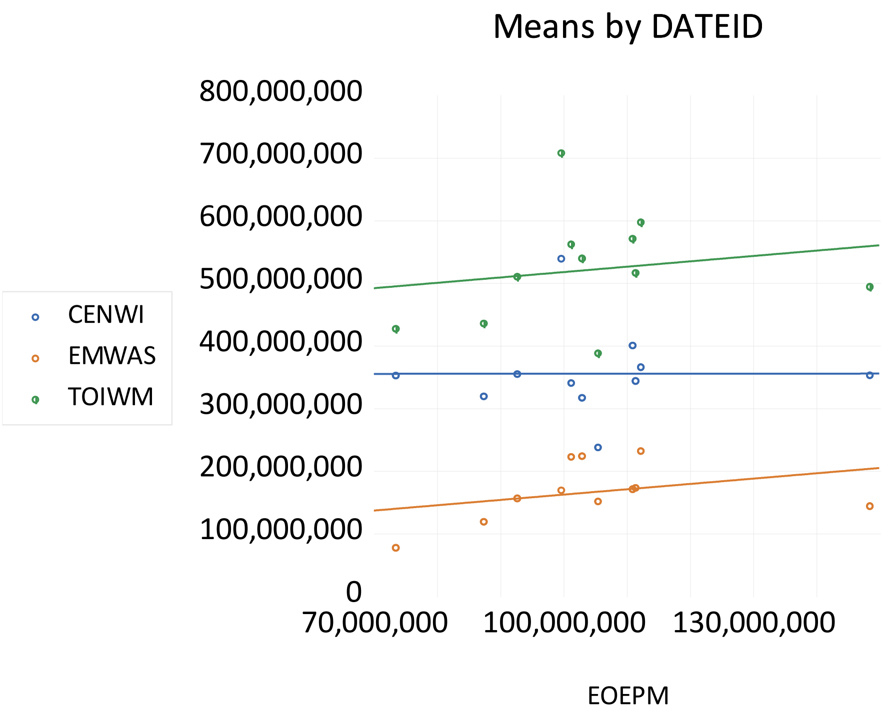

Figure 4.7: Correlation between EOEPM and TOIWM

Source: Researcher's construct

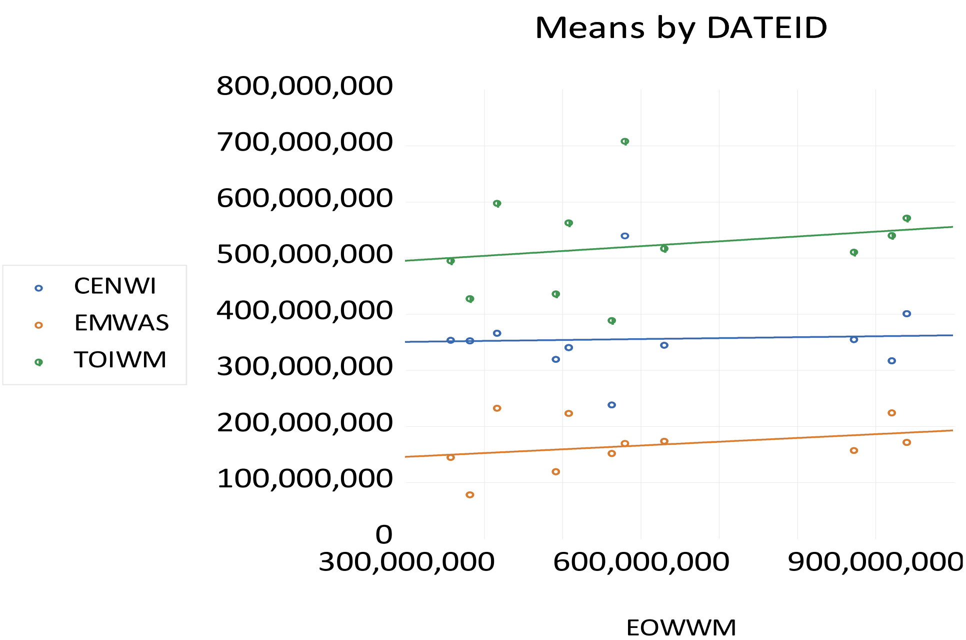

Figure 4.8: Correlation betweeen EOWWM and TOIWM

Source : Researcher's construct

Appendix E: Professional English Editor Confirmation Letter

RMC LANGUAGE PRACTITIONER
117 OOSTVALLEI VILLAGE
657 COLEY STREET
GARSFONTEIN
PRETORIA 0081

TO WHOM IT MAY CONCERN

This is to certify that I have proofread and edited the final version doctoral thesis (DCom) entitled ***Sustainable cities water investment and management for improved water service delivery: a case study of the metropolitan municipality*** by Silas Mukwarami

I applied Microsoft Office Word track changes to the document and have suggested certain changes and corrections to language usage and style which I trust will be effected to make it suitable for publication.

signed:

Date:
11 July 2021

Dr RV McCabe
MA in Applied Linguistics (NWU)
MPPS - Masters in Public Policy Studies (UP)
PhD in English Language Studies (NWU)

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Appendix F: Approval letter from the faculty

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Faculty of Management and Law
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Mukwarami S (201647236) DCOM
SCHOOL OF ACCOUNTANCY
DOCTOR OF COMMERCE (Accounting)

04 July 2019

Dear Mukwarami S,

FACULTY APPROVAL OF PROPOSAL

I have pleasure in informing you that your Doctoral proposal served at the Faculty Higher Degrees Committee meeting on **26 June 2019** and your tittle was approved as follows.

"Sustainable Cities Water Investment and Management for Improved Water Service Delivery: A Case Study of the Johannesburg City Metropolitan Municipality".

Note the following: The study

Ethical Clearance	Tick One
Requires no ethical clearance Proceed with the study	√
Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate	
Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate	

18/07/19

Prof MP Sebola
Chairperson: Faculty Higher Degree Committee

CC: Supervisor and Research Manager Prof MB Fakoya, Prof M.S Tayob and Acting Director of School of Accountancy

Finding solutions for Africa