The mediating role of trade-offs in the relationship between operations strategy and sustainability of Water Utility in South Africa

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DECLARATION

I, Mthunzi Freedom Lushozi, declare that this research report is my own work. It is submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University. I further declare that I obtained the necessary authorisation and consent to carry out this study.

Mthunzi Lushozi

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Signature Date

ABSTRACT

A number of studies on operations strategy and on trade-offs have been commissioned in the past years, however these studies have failed to address the gap on studying operations strategy and trade-offs specifically on the South African water utilities sustainability. To bridge this gap this study investigates whether it is a prudent for the South African water utilities to focus on all five generic operations strategy performance objectives or to trade-off some of them. Quantitative research is conducted where questionnaires were used to collected data from South African water utilities The study aimed at developing an operations strategy trade-offs model to be used specifically on South African water utilities which may also have aspects that are extendable to water utilities elsewhere in Africa or the world. The results for study indicate that water quality, cost and speed were ranked at top three main performance objectives which suggest that not all five operations strategy performance objectives should be focus area where resources are scarce. Furthermore, the results did not support the hypothesis that trade-offs provide a mediating effect on the relationship between operations strategy and sustainability of the water utility. However, as a main outcome the model without trade-offs was supported by the study and this model can now be used by water utilities to test it.

Key words: operations strategy, trade-offs, sustainability and water utilities

PUBLICATIONS

The paper titled "a model for the relationship between sustainability and operations strategy performance of a water utility in South Africa" was presented at South African Institute of Industrial Engineers conference 29 on the 24th of October 2018 which took place in Stellenbosch, South Africa. The authors of the paper were M.F. Lushozi[1] & B. Emwanu[2]

[1]The author was enrolled for a MSc. Eng. (Industrial) degree in the School of Mechanical, Industrial and Aeronautical Engineering of University of Witwatersrand and [2]the author lectures in the School of Mechanical, Industrial and Aeronautical Engineering of University of Witwatersrand. This paper was allocated 3838-1 to 3838-15 on the conference proceedings which was page 791 to 802.

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1. CHAPTER ONE: INTRODUCTION

Chapter one introduces the study. It highlights the background and overview of the current state of affairs regarding South African utilities such as water and electricity. The problem statement, motivation, objectives of the study and outline of the contents of the dissertation are covered in this chapter.

1.1. Background

Infrastructure is the backbone of a successful and competitive economy which requires among others sustainable water and energy (Rhodes, 2018:3). However, the phenomenon of aging infrastructure is a general concern for all utilities not only in South Africa but around the globe. For instance, in the United State it is reported that the Leaders of the utilities in all regions of the country unanimously selected aging infrastructure as their top concern, including pipelines, tunnels, dams, pumping, storage and treatment facilities among the water utility infrastructure (Black and Veach, 2013:10). In European countries according to Guijarro & Rozman (2011:7) water and wastewater infrastructure is over 50 years old and suffers leaks due to lack of pipeline maintenance. African countries such as Botswana have embarked on projects to rehabilitate aging infrastructure as one of the focus areas for their water Utility Corporations (Water Utilities Corporation, 2013:40).

In South Africa it can be argued that the challenges related to utilities infrastructure are to a large extent attributable to how post-apartheid transition was managed. The introduction of apartheid Native Land Act No. 27 of 1913 resulted in deprivation of millions of South Africans living in informal settlements and rural areas of access to basic services such as clean water, sanitation, and electricity (Mhlangeni, 2013:2). Post-apartheid dispensation in South Africa, however revised this policy and as a result the country witnessed drastic changes in the socio-political and economic landscape since the first democratic elections in 1994. For instance, a new constitution was introduced to the country, within which section 27 of the Bill of Rights of the Constitution declared that everyone has the right to have access to sufficient food and water. Therefore, based on this mandate the government started to extend the basic services (such as water and electricity) to a larger population of the country as per this section of the constitution.

However, these basic services were distributed without significantly increasing infrastructure and at the expense of existing infrastructure maintenance (Newberry and Eberhard, 2008:6). In the case of electricity the approach taken contributed to the current challenges faced by the South Africa power utility Eskom of being unable to produce adequate power to satisfy the needs of South African's economy. The struggle undertaken by the power utility to cope with this challenge was characterised by unplanned shutdowns and lack of buffer capacity (Eberhard, 2014). In case of water utilities the lack of adequate maintenance of infrastructure has been reported as one of the factors that contribute to water losses and wastage within the municipalities (Department of Water Affairs, 2014:2).

Mugabi et al (2007:2-6) are of the view that inappropriate strategic management practices in Public water utilities in developing countries results in the enormous challenges they face in meeting the water demands of their growing urban populations. Adopting an operations strategy that seeks to achieve effective asset utilization can assist the utilities deliver on the agreed service level (Asian Development Bank, 2013:12). Service levels of organisations may be considered in terms of performance objectives. According to Slack and Lewis (2011:24) there are five performance objectives that organisations need to focus on namely quality, speed, dependability, flexibility, and cost.

However, it is unlikely that any single organization can excel simultaneously at all of the five operations performance objectives. Trying to focus on all of the five simultaneously is likely to lead to confusion for Operations Managers (Barnes 2008:25). To avoid this situation Collier and Evans (2009) suggested that organizations can use the concept of trade-offs to choose which performance objectives they will give priority above the rest.

Given the scarce resources that the South African water utilities are facing, it is apparent that trade-offs in their operations strategy is critical. Therefore, this study will seek to examine the role of operations strategy trade-offs in the South African water utility.

1.2. Problem Statement

The effective functioning of South African economy for stimulation of economic growth and promotion of employment is strongly dependent on sustainable infrastructure (Perkins, 2012:25). South Africa has a targeted economic growth of about 5% by 2030 of which sufficient water infrastructure is one of the key contributors to achieve it (Department of Water Affairs, 2014: 2).

As a result of the new (post 1994) democratic government embarking on an ambitious program to eradicate the supply of clean water only to the selected few (Water and Sanitation Programme, 2011:2), there is increased demand on the existing infrastructure to deliver more water. However, the predicament is that the major part of South Africa's bulk water infrastructure is reaching the end of its life span which will result in a need for upgrading or replacement. Moreover, the lack of maintenance occasioned by inadequate infrastructure has exposed strategic systems such as Vaal and Umgeni to unacceptable risk of water restrictions for the next decade (South African Institute of Civil Engineering, 2011:14). This means that the possibility of a breakdown and failure of the infrastructure to meet demand may be imminent, leading to a nation-wide crisis of water supply similar to that witnessed in the power utility sector in South Africa in recent times.

While the South African water utility infrastructure has not reached the alarming state of the power utility, inspiration is drawn from the challenges recently faced by the power utility to guide the water utility on where to emphasise its service delivery efforts to achieve maximum overall impact even as it attends to long-term capacity needs. This requires assessing the current status of its infrastructure in relation to the operations strategy performance objectives and determining the trade-offs thereof. This would help identify the most appropriate performance objective to focus on for effective service delivery that the utility should expend its limited resources on in the current challenging circumstances; such direction has not been clear at the time of embarking on this study.

1.3. Purpose of the Study

The primary purpose of the study is to examine the current state of South African water utilities infrastructure with respect to the five performance objectives (cost, dependability, flexibility, quality and speed) and their trade-offs, and how this relates to its sustainability.

1.4. Research Objectives

The research objectives are:

1. To characterise the main activities of a water utility in terms of operations strategy matrix, in particular performance objectives (cost, dependability, flexibility, quality and speed).
2. To assess the extent of importance of each of the five generic operations performance objectives namely cost dependability, flexibility, speed and quality in South African water utilities
3. To determine the current state of infrastructure maintenance and infrastructure capital expansion plans.
4. To determine which of the five generic operations performance objectives rank higher than others for a water utility.
5. To develop a trade-offs model for operations strategy in a water utility in South Africa.

1.5. Research Question

What is a better option for the South African water utilities, to focus on all five generic operations strategy performance objectives or to trade-off some of them?

1.6. Scope and delimitations of the study

This study focuses on three main variables which are trade-offs (mediating variable), operations strategy (independent variable) and sustainability of water utility (dependent variable). The main respondents are the water utility employees working at operations, maintenance, strategic asset management, projects and projects support which included both managers and none managers. The coverage is provincial and targeted water utilities within one selected Province.

The scope for this study is limited to the examination of trade-offs on water utility operations strategy for its sustainability drawing from some learning on power utility crises. However, the political influence that contributed to power utility struggle is not explored in details as it is deemed to be outside the scope of the study.

1.7. Research Motivation

There have been numerous studies on operations strategy and on trade-offs, however there has never been a study on both operation strategy and trade-offs specifically on the South African water utilities. This study seeks to bridge that gap and develop an operations strategy trade-offs model to be used specifically on South African water utilities, and may also have aspects that are extendable to water utilities elsewhere in Africa or the world.

1.8. Assumptions

This study is based on the assumption that South African water demand in future will continue to increase at the rate it is currently increasing or higher. The study also assumes that water utilities will continue to be under government's control which influences how they are managed and how the infrastructure expansion is funded.

1.9. Report Structure

Chapter 1: Introduction- presents the introduction of the study, background for statement of the problem, research question, significance of the study, scope and delimitations of the study.

Chapter 2: **Literature review-** contains the review of literature and research related to the problem being studied. It includes analysis of the South African power utility crisis, further look at water utility current status and future thereof.

The theory of trade-offs is looked at in this chapter together with operations strategy in general. This chapter further presents the hypothesised model and study hypothesis.

Chapter 3: Research methodology-the methodology and procedures that were used to gather data for the study are presented in Chapter 3.

Chapter 4: Results presentation –The results of the study are presented in this chapter with little or no discussion.

Chapter 5: Results discussion –the detailed discussion of results is presented in this chapter. This chapter also presents the final model recommended by the study.

Chapter 6: Conclusions and recommendations: conclusions that are drawn from the findings and recommendations for further study are presented in this chapter.

2. CHAPTER TWO: LITERATURE REVIEW

In this chapter the key concepts relevant to this study will be reviewed. Firstly, the operations strategy will be defined and its components highlighted. Furthermore, operations strategy theories are discussed and critical review of these theories is made; the sustainability of South African utilities is also discussed. It looks at the relationship of the operations strategy to the water utilities sustainability and reviews the previous studies on operations strategy models. Lastly, it develops the hypothetical model and outlines the hypothesis to be tested later in the study.

2.1. Theories and Models

There are various operations strategy models in the literature however, this study has focused on three which are Skinner (1975), Hayes and Wheelwright (1984) and Hill (1985) which are discussed in table 2.1. This table looks at the similarities and differences of these models.

Table 2.1: Comparison of concepts by various schoolars

Concept	Author	Similarities	Differences
Focused factories	Skinner (1975)	Skinner's concept of trade-offs and Hill's model show similarities and synergy in some respect on approach. For instance, Hill talks about order qualifiers and winners which are specific elements that clients look for in a product. On the same note Skinner talks about putting focus on elements that are performing more than others. Therefore, there should be more focus on performance objectives that contribute the most to what was determined by clients as order qualifiers and winners. Alternatively, whatever seems to be the organisation's high performing objective could be aligned to ensure that it takes the organisation from qualifying for an order to winning the order.	Skinner's model shows some differences with respect to both Hayes & Wheelwright approach and Hill's approach. Consider trade-offs as a case in point, these do not necessary assume stages from one to another and could be introduced into organisations at any stage, whereas in both Hayes & Wheelwright approach and Hill's approach the organisations are assumed to be at a specific stages of development from one stage to the next, whereby each stage will necessitate different trade-offs.
Four stage model	Hayes and Wheelwright (1984)	Hayes and Wheelwright's four stage model shows similarities with both Skinner's and Hill's concepts in that to move from stage 1 to 2, trade-offs could be vital in putting more focus on what is working and less focus on what is not working well for the organisation so that it is able to achieve parity with competitors. Moreover, when the organisation is at stage four, trade-offs would support the company to gain and maintain manufacturing based competitive advantage.	
Five steps model	Hill (1985)	Hill's model appears to be accommodative of both Skinner's trade-offs concept and Hayes and Wheelwright approach. For instance, in step 3 of Hill's model an organisation can segment the market based on its strengths with the reference to how these are designed to order winners and qualifiers. However, after segmenting the market the organisation may have to trade-off some performance objectives which are not strong in that market segment.	

Whereas the three concepts, namely focused factories (Skinner 1969),) four stage models (Hayes and Wheelwright, 1985) and five step model (Hill, 985) have been applied in various industries, no literature was found on their application in the utilities sector, neither power nor water industry. Nonetheless, studies have shown that trade-offs contribute to the sustainability of an organisation. For instance, Winn et al (2012:63) in their study of corporate sustainability demonstrate that trade-offs play an integral role in the sustainability of the organisation, and argue that sustainability requires effort and is not just another business.

2.2. Definition and Components of Operations Strategy

The success of an organisation is dependent on having an effective and clearly defined operations strategy (Amos, 2014:47). The operations strategy is normally formulated based on the competitive advantages of the organisation (Kaviani & Abbasi, 2014: 371).

2.2.1. Definitions guiding the study

Different scholars have defined operations strategy differently. For instance, Skinner (1996:332) describes it as a set of manufacturing policies designed to maximize performance to meet corporate strategy, alternatively, it is a total pattern of decisions that shape the long term performance of the organisation (Slack and Lewis, 2011:24). On the other hand, Walters (2006:120-123) argues that operations strategy is more than a set of decisions and suggest that it is more about long term goals, policies, culture and resources, and decisions that relates to operations.

2.2.2. Operations strategy components

According to Slack and Lewis (2011:24) there are five generic operations performance objectives and four operations decision areas. The five operations performance objectives are cost, quality, speed, dependability and flexibility; while the four decision areas are capacity, supply network, process technology and development and organisation. These performance objectives and decision areas are better represented in a matrix form as in figure 1 which is called an operations strategy matrix model. An effective operations strategy should maintain and improve competitive advantages of the organisation based on their corporate operations resources capabilities (Kaviani & Abbasi, 2014: 371).

2.2.3. Generic Operations Performance Objectives

2.2.3.1. Quality

According to Knowles (2011:10) quality in the manufacturing fraternity is defined as a product’s level of conformance to specifications and critical customer expectations. He notes that organisations often use tools such as statistical process control, six sigma and standardisation to improve quality. Slack and Lewis (2011:48) define quality as the consistent conformance of a product or service to customers' expectations. Standardization and careful attention is vital in assisting organisations to maintain high and consistent quality level which ultimately leads to profitability of the organisation (Sprague, 2007: 221). On his manufacturing strategy model Hill (1994) suggested that performance objectives can either be order qualifiers or order winners. Quality is no exception to that. For instance, a certain quality level may be prescribed that one should meet to be able to qualify to receive any orders at all (Maylor *et* al, 2015:107). A water utility is a good example of an organisation whose product requires a certain level of quality for one to get an order in accordance with South African National Standards (2006) 241, as illustrated in table 1 below.

Table 2.2: South African National Standards 241:2006 Classification of compliance

1	**2**	**3**	**4**
Quality of water system	Microbiological requirements	Chemical requirement	
	Column 5 of table 1	Class I	Class II
Excellent	≥ 99%		
Good	≥ 98%		
Fair	≥ 97%		
Poor	‹ 97%		

This standard suggests that in order to get an order to supply water into the drinking water services system, the quality of water must be classified as excellent in table 1. Therefore, according to table 1 the operations that produces quality which is classified as poor in table 1, do not qualify to get an order.

2.2.3.2. Cost

Cost can be described as an absolute term and measures the amount of resources used by the organisation's operations to produce the product (Hallgren, 2007:12). The cost in water utility would involve mainly operations cost, plant maintenance and capital expansion.

2.2.3.3. Flexibility

This is the ability of operations to easily change product mix and production volumes in response to the market demands (Minterburg, 2005:45). Amoako-Gyampah & Acquaah (2007:579) maintain that organisations with reliable and on-time deliveries can anticipate greater customer satisfaction that can potentially lead to increased sales growth and market share. Hallgren (2007:12) argues that a characteristic that differentiates flexibility from other dimensions of operational performance is that it is a measure of potential as opposed to actual performance. The ability to change water supply volumes with demand would constitute flexibility in a water industry.

2.2.3.4. Dependability

Dependability in the manufacturing fraternity measures the ability of an organisation to keep delivery promises made to the customer (Slack & Lewis, 2011:50). It is an ability of the organisation to do things in time for their customers to receive their product exactly when they are needed, or at least when they were promised (Indran, 2007). Customers normally gauge if the product required was delivered on time or not (Vencataya, 2012:11). He suggests that dependability is both internal and external.

According to Awwad et al (2013:72) external dependability is usually regarded by customers as a good thing because being late with delivery of product can be a considerable frustration to them. Dependability can be a determining factor sometimes that is used by clients to determine whether suppliers have their contracts renewed (Hallgren, 2007:6-7). It is therefore clear that the external effects of this performance objective are to increase the odds of customers returning with more business (Awwad et al, 2013:72). According to Russell & Millar (2014:77) dependability is consistent with quality. Internal dependability can result in the utility saving time by saving money directly or giving the utility stability which allows it to advance its efficiencies. Highly dependable systems can assist increase speed performance (Hallgren, 2007:6-7).

2.2.3.5. Speed

Speed indicates the elapsed time between the beginning of an operations process and its end such as the time taken to fulfil the customer requests (Slack & Lewis, 2011:48). Minterburg (2005:45) defines it as the time taken by manufacturing process to deliver the required product to the customer. According to Jeena (2002:87) improved speed assists operations influence the time taken for goods and services to be delivered to the customer, she is of the opinion that externally, speed is a significant facet of customer service, while internal it decreases throughput time and reduces risks by delaying the commitment of resources. Therefore, in water utility, speed would be associated with the time taken by treatment plants to clean up water and pump it to strategic reservoirs.

2.3. Operation Strategy

Having considered the definition and components of operations strategy in section 2.2 this section expands on the theory and models in operations strategy. Skinner's (1969) work titled "Manufacturing-missing link in corporate strategy" was a preface to the introduction of manufacturing and operations into the strategic decisions of companies (Kaviani & Abbasi, 214: 375). Subsequently different scholars followed suite by coming up with their different operations strategy models. For instance, Hayes & Wheelwright (1984) introduced their four stage model; a year later Hill (1985) came up with his framework for strategy formulation. In the 90s Voss (1995) and Hayes & Pisano (1996) introduced resource based view of manufacturing strategy which consists of adapting capabilities of the firm to match market requirements. The development of these operations strategies and several others were inspired by Skinner's theory of trade-offs.

2.3.1. Theory of Trade-offs

Effective operations strategy requires an awareness of trade-offs, whereby management is able to consider the different variables required to achieve set objectives and have the ability to trade one against the other, to optimise the chances of success (Slack and Lewis, 2002:85). According to Skinner (1992) a trade-off scenario is one in which a high, market-leading performance in one competitive criterion (e.g. flexibility) is achieved at the expense of lower levels of performance in a different capability (e.g. speed). Filippini *et* al. (1998:3383) maintain that two types of performance are in trade-off if the achievement of high values in one type of performance means low values in another. Therefore, a trade-off situation is characterized by high levels of difference between the two types of performance (Sarmiento, 2011:4182). According to Skinner (2007:335) it is paramount to recognise the variables that can be controlled and then to focus on them.

In his article ‘the focused factory”, Skinner (1974:119) argues that manufacturing plants should have specific and concise tasks with regard to their products, technologies and markets. He suggested three different dimensions of focus: Product focus: producing a narrow mix of products; market focus: serving a carefully and narrowly defined market segment or niche and process focus: focusing on a certain type of production technology.

Clark (1996:45) suggests that organisations that attempt to excel on everything without developing competitive priorities will end up second best to organisations that focus theirs. The focused factory theory is based on the premise that no single organization can do equally well in all things. Applying this perspective to water utilities, this suggests that it is not critical to be perfect in all aspects of water delivery from source to consumer; rather by focusing on one or two manageable objectives water utilities should be able to improve their service and efficiency in the long term. Subsequent to Skinner’s (1974) work, Hayes and Wheelwright (1984) and Hill (1985) continued to emphasize the importance of operations strategy and expand on it.

2.3.2. The four-stage model of the strategic role of operations

Hayes and Wheelwright (1984) developed a four-stage model for operations strategies of organizations. Their model traces the evolution of the operations function from what is the largely negative role on Stage 1 to it becoming the central element of competitive strategy in excellent Stage 4 (Slack and Lewis, 2011:240-241). This model describe stage 1 and 2 as internally neutral and 3 and 4 as external supportive as the organisation from move from stage 1 to 4 towards increasing contribution of operations. It argues that redefined industry expectations (stage 4) provides an operations advantage from stop holding the organisation back (stage 1) which assist the organisation to correct the worst problem they are facing.

2.3.3. Five Steps Operations Strategy Model

According to Hill (1994:45) clear understanding and agreement about the markets in which the organisation wishes to compete is fundamental in the formulation of operations strategy. He developed a five steps model that provides an analytical and objective structure to develop operations strategy. The first step of the model defines corporate objectives such as return on investment, profit, survival, growth among others. The next three steps are determining the marketing strategy in order to meet these objectives, assessing how products qualify and win orders against competitors, establishing the appropriate process choice for manufacturing. The final step is ensuring that the infrastructure necessary to support the competitiveness of the firm is provided and safeguarded (Hill, 1989;).

According to (Ullstrom, 2008:6) it is at stage three that manufacturing strategy issues are connected with marketing requirements. He however suggests that, the stages do not necessary work independently or in sequence, but have to be integrated. Hill (2009) in his work furthered his framework "Linking Manufacturing to Strategy" in terms of competitive advantage by considering criteria for order qualifiers and order-winners.

Holmberg and Moflag (2013:25) maintain that order qualifiers are elements that an organisation considers when deciding whether or not to buy a service or product from one company or another. Qualifiers are offers that are considered in an adjudication process and potentially qualify the supplier into the purchasing process, while winners are those offers that proceed to the final stage where the selection of one order is done. Swink *et* al (2011) argue that organisations use order qualifiers and order winners to understand and identify their customers' wants and needs in order to have competitive advantage.

The steps an organisation should follow in order to identify the order qualifiers and winners starts with segmenting the market based on factors such as demographic, geographic, psychological and behavioural factors. Segmenting the market assists the organisation have a better understanding of their target audience and thereby make their marketing more effective (Larsen, 2010: 6). This is followed by identifying a sample for each segment to define and understand the segment and its dimensions, time period and behaviour of change overtime. Lastly, analysis and forecasting of the volumes of each segment within the time period is done.

2.4. South African Utilities and Sustainability

In 2010 South African Government introduced the New Growth Path (2011) as a strategy to build an inclusive economy and thus create decent employment, sustainable livelihoods and eradicate poverty and income inequality. According to National Growth Path (2010:2) these are primary components of economic growth and economic development. Eberhard and Gratwick (2013:9) maintain that economic and social development depends fundamentally on infrastructure, for which electricity and water are among the most critical inputs. A closer look at the Power Utility crisis provides a reasonable basis for the water utilities sector to learn from. The challenges faced by the power utility and their impact to the South African economy are well documented.

2.4.1. Power Utility Crisis

The study conducted by Organization for Economic Cooperation and Development (2013:11) suggests that South Africa has experienced a relatively weak recovery from the 2008-09 recession. It maintains that this is as a result of electricity supply limitation which has constrained potential output growth in the country. The national electricity supplier Eskom cannot supply all the power demanded by the market because it cannot add enough new power generation capacity in time and the performance of its existing power plants is declining quickly (Eberhard, 2014). Eskom was seen as vital to the development of the state with the new generation plants Medupi and Kusile meant to power the economy into the future. However, these new power stations are years late and over budget which is constraining rather than facilitating economic development (Eberhard, 2014).

It is widely accepted that maintenance and capacity expansion of power generation have a crucial role to play in the future sustainability of the power utility. For instance, a few years earlier it had been predicted that Eskom's aging and badly maintained power stations coupled with a major skills shortage would lead to a power crisis in the next few years (Solidarity, 2008:9). As this eventually happened it could be deduced that the load shedding experienced in the country was attributed to poor planning and lack of plant maintenance which hindered economic growth and affected employment targets negatively.

Joffe (2013:32) maintains that energy efficiency is key to shaping the environment as electricity supply with more capacity is required for future sustainability. Inglesi and Pouris (2010:50) suggest that some of the major challenges faced by the power utility in ensuring continuity of supply and successful execution of the capacity expansion programme was the lack of good decision making by the Government. The power and water utilities are facing the same challenge which is the struggle to keep up with demand (Organisation for Economic Cooperation and Development 2016:8). However, the sources of the challenges faced by the water utility may not necessary be the same as those of the power utility. They are both state owned and both are at the centre of the country's economic development. Therefore, there can be parallel learning from each other.

2.4.2. Water Utility

Southern Africa is largely a water scarce region in which a majority of people lack access to basic safe water and appropriate sanitation (Regional Water Infrastructure Programme 2011:3). In the 2000 Millennium Summit, the United Nations established eight key goals which were named Millennium Development Goals (MDGs). According to Mugisha et al (2006:2) the achievement of MDGs demands significant managerial innovation and creativity, especially in low-income countries where utility inefficiencies are still most prevalent. The same view is reflected in SADC's Regional Infrastructure Development Master Plan (2009:5) which asserts that some of the key ingredients for SADC region to stimulate growth and achieve the MDG are least cost energy supply, and cost-efficient water supply.

At present water usage in South Africa exceeds reliable yield and there is a threat that changes in climatic conditions, for example a drought, could result in wide- spread restrictions on water usage across the country (Department of Water Affairs, 2013:3). It is estimated by Department of Water Affairs (2013) that over 36% of water supplied in South Africa is non-revenue water which means that it is either lost in the system through leakage (lack of maintenance) or abstracted through unauthorised means. In addition, only 3% of Water Services Authorities are operating in a satisfactory manner, whilst a further 18% are at risk, 33% at high risk and 46% are in crisis. These challenges are attributed to factors such as processes operation, maintenance of infrastructure, revenue collection, water service quality, customer service, demand management and water conservation (Department of Water Affairs 2013:35-38).

Holt (2014:6) argues that the water utility is a capital intensive industry because most major components of the process require fixed capital investments in long term infrastructure assets. There is inadequate water sector infrastructure and storage to exploit water resources available to the SADC citizens for them to utilise for their economic and social benefit (Southern Africa Development Committee, 2012:11). According to the South African Institute of Civil Engineering (2011:5) score card, the ageing bulk water infrastructure portfolio has experienced further deterioration as a result of insufficient maintenance and neglect of ongoing capital renewal.

The South African government projected a capital investment (Capex) for water supply of about R11.2 billion per year (Water and Sanitation Programme,2011:9). As shown in figure 2.6 below there was a shortage of supply compared to the required demand based on their plans for 2015 and beyond.

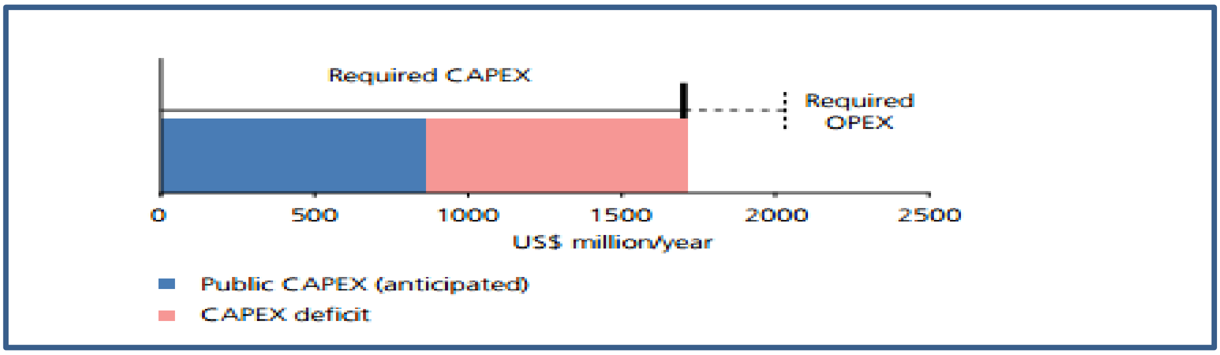


Figure 2.1: Required versus. anticipated (public) and assumed (household) expenditure (African Ministers' Council on Water, 2015:9)

The South African government has had to increase its capex forecast so as to keep up with the capex required to improve water infrastructure. More than 95 percent of this capex is public while the remainder is house-hold. There is an increase in domestic water requirements and this calls for development of additional water resources (Department of Water Affairs, 2013:8). This development required an additional funding for new bulk infrastructure of about R50 million to R1000 million per project category. In terms of value for money, South Africa's average per capita investment requirement is expensive compared to the entire region as a result of inefficiencies within the sector context of investment (Water and Sanitation Programme 2011:9). Despite those inefficiencies and high water cost, South Africa still needs water for their economic development. In South Africa water is used in various economic sectors as shown in figure 2.2.

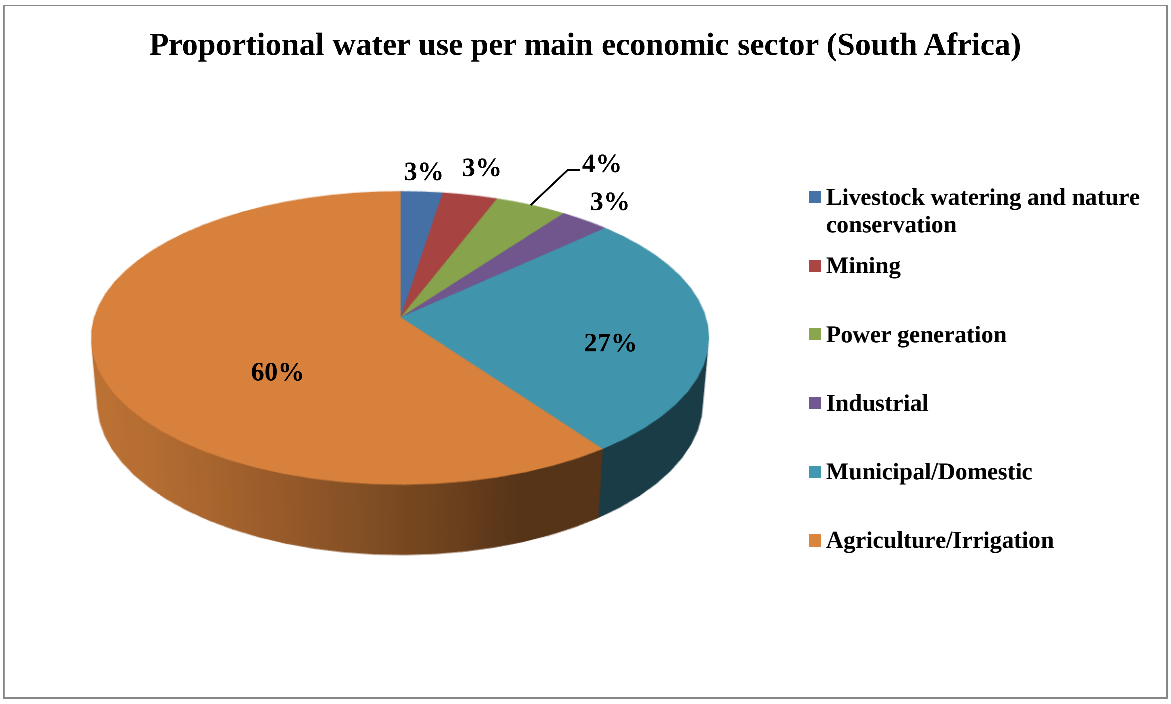


Figure 2.2: Water usage per economic sector (Water and Sanitation Programme, 2011:9)

Agriculture uses most of the water resource with 60% consumption followed by municipalities which distribute the water for domestic use both rural and urban with 27% consumption. The two combined constitute about 87% of the total supplied water in the country. The rest of the supply is shared out in economically active sectors or enablers. This suggests that the sustainability of utilities is imperative for South Africa to grow or at least sustain its economy. Therefore, maintenance and capital expansion of the water utility infrastructure is considered next.

2.5. Utility Sustainability: Maintenance and New Infrastructure

At the World Summit on Sustainable Development that was held in South Africa former President Nelson Mandela said: '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' (Msangi, 2014:21). On that note the importance of sustainability of water utilities cannot be over emphasised.

According to (Environmental Protection Agency, 2013:2), utilities that efficiently integrate sustainability considerations into their operations strategies can expect to accomplish numerous benefits such as minimizing costs, maximising investment results, improvement of the ability to analyse a range of alternatives, and ensuring that financial and revenue strategies are sufficient to finance, operate, maintain, and replace critical infrastructure throughout its operational life.

Water and Sanitation Programme (2011:123) point to research indicates that the water demand in South Africa will exceed supply by 2025 if the current water resources are not supplemented. They warn that the sustainability of the water sector as a whole is also under threat due to the poorly maintained and often ill-equipped infrastructure. The primary objective of maintenance is to slow down asset deterioration and extend the period before rehabilitation and renewal is required (Mannan 2012:196). He maintains that, normally plants apply a mix of preventive and breakdown maintenance. International Water Associations (2011:9) also assert that the plant maintenance seeks to enhance the effectiveness and sustainability of capital investments and existing infrastructure for water utilities. This point is highlighted in a study conducted by Mutloane (2009:1) that reveals that Eskom power stations are operated at about 90% of the times as opposed to the world norm of 75%. This implies that Eskom presents little time to do effective maintenance on the plant compared to the world norm. At Eskom the increasing trend on Unplanned Capacity Lost Factor (UCLF) percentage is an indication of the deteriorating plant health and the high plant utilisation (Eskom 2011). Therefore, there is a need to balance adequate maintenance with the constrained system, asset creation, environmental requirements and available financial resources

In order to meet increasing demand for water and to avoid the repeat of the power utility crisis occurring in water utilities as well, water utilities should strengthen their plans to improve the management of scarce resources. Moreover, expanding access to water requires investments along the key supply chain components such as dams, bulk water supply schemes and wastewater infrastructure (South African National Treasurer 2013:19). Department of Water Affairs and Forestry (2009:30) believes that Asset Management is fundamental in the maximization of the value of an asset over its lifecycle; thereby ensuring that the water utilities derive the most benefit from its investment. This comprises of constructing, operating, repairing or replacing assets at the optimum time to ensure system reliability at the lowest cost and least impact to the utility.

2.6. Empirical Literature Review on Operations Strategy, Trade-offs and Sustainability

This section briefly looks sat the approach used in three previous operations strategy studies that are relevant to this study such as focus on determination of trade-offs, qualifiers and wining criteria and how key components of operations studies interact.

Kyengo (2014) undertook a study within the metal and allied sector in Kenya to establish factors that are critical to the selection of manufacturing strategy and whether there was a relationship between manufacturing strategy and Operational performance. This was a Descriptive study with data collected in 71 firms in Kenya. A self-administered questionnaire consisted of both open and close-ended questions were used to collect data; some of which were on the operations strategy performance objectives of cost, quality and flexibility.

The data were analysed to compare competitive priorities to determine the variable most important for competitiveness of organisations in the steel industry of that country with the aim of determining the trade-offs. This study adopts a similar approach in determining trade-offs within the water utility sector. In addition Kyengo (2014) found that there is a relationship between manufacturing strategy and operational performance which implies that organisations that adopt and implement manufacturing strategies are likely to benefit from improved operational performance and hence develop competitiveness. This was found to be in-line with the Skinner (1975) theory of trade-offs. Similarly, this study aims to examine relationship between operations strategy, sustainability and trade-offs.

Using Hills five step model Menda (2001) conducted a study to determine operations strategy and identify market qualifying and order-winning criteria in manufacturing firms. He used the case study and action research methods with data collected from various sources such as documentation (i.e. reports and memos), archived records (i.e. organisational records and diaries), interviews, direct observations, practical observations and physical artifacts. Five case studies were covered. Some elements of Menda's (2001) study were adopted to create the questions of this study's questionnaire.

Al-Rasby (n.d: 2) considered Hayes and Wheelwright 4 stage model and was sought to determine the key components to give strategic role of manufacturing. He used priori methods in his study. This study also used priori methods during the early stages of the study to determine the information to put on the questionnaire.

2.7. Hypothesised Model

Figure 2.8 is the hypothesised model for the study. This model hypothesises that operations strategy (independent variable) has a significant relationship with water utility sustainability (depended variable) and trade-offs (latent variable).

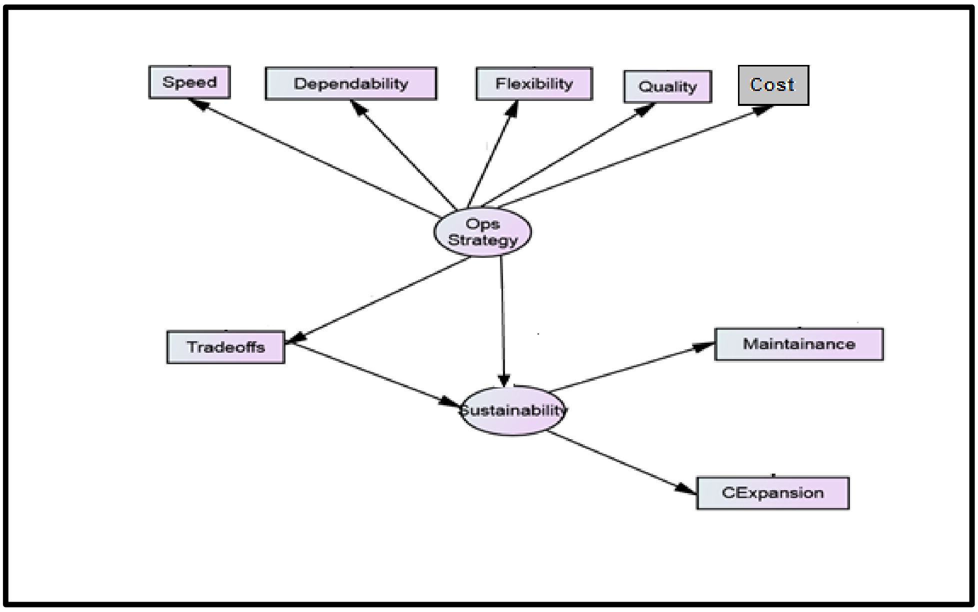


Figure 2.3: Hypothesised model

The operations strategy is measured by using the operations strategy performance objectives such as cost, speed, flexibility, dependability and quality. On the other hand, water utility sustainability is measured by current maintenance status and capital expansion status. The model considers the following three hypotheses:

- **H1**: operation strategy has significant and direct effect on water utility sustainability.
- **H2**: operation strategy has significant and direct effect on trade-offs.
- **H3:** trade-offs has significant and direct effect on water utility sustainability.

These three hypothesis were derived from findings such as the one of Kyengo (2014) that established that there is a relationship between operations strategy and organisation's operational performance. For this reason the study argues that an organisation (water utility in this case) depends on operation strategy for its sustainability. The mediating element of trade-offs was hypothesised form the fact that operations strategy has various elements as outlined by Slack and Lewis (2011) which cannot be satisfied all at ones according to Skinner (2007). Given these considerations it is argued that operations strategy will be an independent variable, sustainability will be a dependent variable while trade-offs will be a mediating variable.

3. CHAPTER THREE: RESEARCH METHODOLOGY AND DESIGN

3.1. Methods of Research Used

Research can be progressed using a number of research strategies, such as quantitative, qualitative or mixed-methods approach (Andrew *et al* 2011:47-48). This study was conducted using a quantitative method. However, in order to develop a questionnaire a qualitative preliminary study was conducted where few experienced employees engaged in order to refine questions. This was not research per se. The strategy was to develop a conceptual framework on a step by step basis beginning with locating the applicable theory to developing an initial framework that gets refined progressively to a more realistic framework that fits the data obtained from the field. Diagram 3.1 illustrates the steps that were followed to conduct this study.

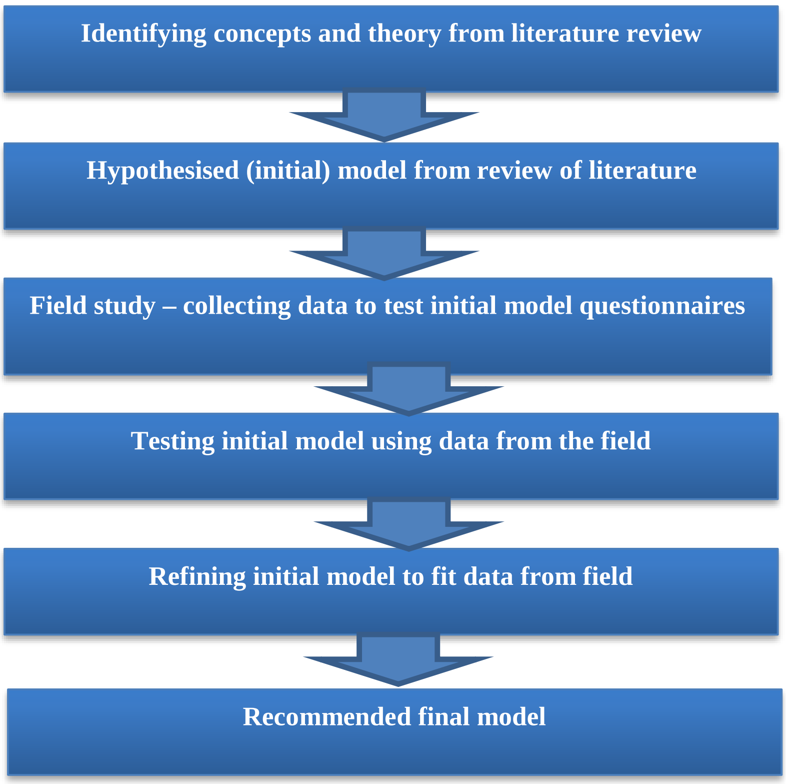


Diagram 3.1: methodology and design steps

The first step was to identify relevant concepts and theory from the literature so as to develop an initial hypothesised model. When this was done, an instrument was developed to collect relevant data from practitioners in the field, basing on information from literature and considering the relationships investigated. Data collection was done using a questionnaire to obtain primary data from South African water utilities. The data were used to test whether the framework fits the data. Where it did not, adjustments were made to the model that led to the final conceptual model.

3.2. Measuring Instrument

A questionnaire was used to collect data for the study (see appendix 1). It was composed of closed-ended questions developed specifically for this study. The questionnaire was personally administered to the respondents. The questionnaire for this study used nominal and likert scales. The nominal scale was used for demographic information and the likert scale was used for all other sections of the questionnaire in line with Simon & Goes (2013) recommendation.

After the constructs were developed in a form of hypothesised model on figure 1 more consideration was given to the hypothesised constructs and items were then designed. The design of the items was done through the combination of literature and preliminary qualitative study that engaged experienced people in the field of water utilities. The items were designed to measure specific aspects of the construct. The constructs were divided as follows:

- Section 2: considered speed, cost, quality, flexibility and dependability which were the sub-constructs of the operations strategy construct. Each construct had an average of 5 items.
- Section 3: considered trade-offs which had 5 items and performance objective importance ranking construct which also had 5 items.
- Section 4: considered infrastructure status which had 2 sub-constructs which were maintenance and capital expansion. These sub-constructs had 5 items each.
- Overall the questionnaire was divided into four sections as outlined below:

Section one: This section consisted of demographic information being respondent’s age, gender, highest qualification, current position and department.

Section two - operations performance objectives: This section used a five-point likert scale to test importance of each of the five operations strategy performance objectives (speed, cost, quality, flexibility and dependability) and was presented as follows:

Table 3.1: sample of the questionnaire scales

Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

Section two had 25 items in total.

Section three – trade-offs: This section was used to identify the trade-off between the five operations strategy performance objectives. The respondents were asked to rank the performance objectives from 1 to 5 in the order they believe to be most important. This section had 5 items.

Section four – infrastructure status: This section used a five-point likert scale to assess the status of the current infrastructure and capital expansion plan thereof. The section comprised of 10 items in total.

3.3. Target Population: population and sample

When conducting research, it is a challenge to study the entire population of interest therefore it is recommended that a researcher uses a sample as a way to gather data (Burns and Burns, 2012:28). A sample is a subset of the population being studied that represents the larger population (Gaur and Gaur,2009:35). It is used to draw inferences about the entire population without having to measure it. The target population for this study were all employees that work for the water utility and water boards, both professionals and non-professionals. The reason for choosing to use people at all levels was to get a broader view. This encompasses both males and females of all races, ages and working experience with any qualification.

A stratified sampling technique was used for this study as opposed to random sampling and others. This is a sampling technique in which the researcher divides the entire target population into different subgroups, or strata (Welman et al, 2010:24). Strata were defined across the different key strategic departments of water utilities such as maintenance, operations, projects support and capital project in order to achieve a good representation of all relevant departments; within the strata a convenience sample was used. This method was applied to ensure that within the employees under these specific departments were the ones that could give meaningful contribution to the study because of their direct involvement on the issues the study is trying to establish.

3.4. Sample Size

The questionnaires were issued to 70 people excluding those that were issued for pilot testing of the questionnaire. Only 62 respondents responded of the 70. Out of the 62 who responded, only 51 were completed in full and 11 were not completed fully.

3.5. Data Collection and Pilot Testing

The research was a field study being conducted in a natural working environment on the water utilities where respondents were located. The data to answer the research question were collected over the period of two and half months. Therefore, the study was a cross-sectional study.

Sekaran (2000:245) suggests that a pre-testing stage assists the researcher to identify and remove any ambiguities, biases, problems with wording and/or measurement before the full-scale data collection process starts. Therefore, the questionnaire was pre-tested on one of the water utilities business unit to ensure that the questions contained therein were meaningful and was fully understood by the respondents. This assisted in the identification of ambiguities, biases or wording problems before the real survey. There were minor flaws that were detected such as spelling errors and these were corrected prior to the main survey.

3.6. Data Analysis

Statistical Package for Social Sciences (SPSS) was used for data analysis. The mean, range, the standard deviation and the variance in the data were used to get an indication of how well the questions were constructed and how good the scales were (Sekaran, 2000:307). Cronbach alpha coefficients were used to assess the reliability of the measuring instruments. Pearson product-moment correlation was utilised to identify the relationship between the studied variables. A step-wise multiple regression analysis was conducted to determine the proportion of variance in the dependent variables of utilities sustainability that will be predicted by the independent variables (trade-offs between maintenance and capital cost). Descriptive statistics including frequency distributions, histograms, pie charts and bar diagrams was used for personal data or classification variables such as the number of professionals in the subpopulations, their gender, number of years worked and level of education among others.

3.6.1. Regression analysis

According to Chatterjee and Hadi (2006:1) regression analysis is a methodology used by scholars to estimate the strength and direction of the relationship between two or more variables. This study used regression analysis to determine the relationship between operations strategy and sustainability of operations strategy and trade-offs; and between trade-off and sustainability. This was done to determine whether the relationship supports the hypothesised model.

3.6.2. Pearson product

According to Gomm (2009:68) the extent of the statistical relationship between two interval or ratio level variables is described by a summary measure called Pearson product-moment correlation coefficient. He asserts that the correlation coefficient is scaled so that it is always between -1 and +1 and when it is close to 0 means that there is little relationship between the variables and the farther away from 0, in either the positive or negative direction, the greater the relationship between the two variables. For this study correlation coefficient was used to measure the strength of a linear association between operations strategy and sustainability; and between trade-offs and sustainability in order to confirm the hypothesized framework.

3.6.3. Structural Equation Modelling

Structural Equation Modelling was performed using AMOS 20 (Arburkle, 2013) to test for mediating effects of trade-offs in the relationship between operations strategy and water utility sustainability. The hypothesised model on figure 2.8 is a mediation model in which operations strategy influences the water utility sustainability with trade-offs playing a mediating role in this relationship. A closer examination of the direct and indirect effects to evaluate their relative sizes was done.

3.6.4. Testing Relationship between Variables

In this study Pearson product-moment correlation was used to identify the relationships between the variables. The study has hypothesised that there is a significant relationship between three variables of interest. Therefore, this was used to test significance among the variables. The effect size measure the cause and effect in the relationship between variables (Steyn, 1999). The following parameters 0.01 (small effect), 0.09 (medium effect) and 0.35 (large effect) were set for practical significance (Steyn, 1999).

3.7. Reliability

Reliability is a measure of the extent the researcher can rely on the source of data and the data itself. Internal consistency is the main measure of reliability since reliable data is the one that is dependable (Pierce 2008:84). Cronbach's alpha coefficient is the most commonly used method of assessing internal consistency reliability estimates (Malhotra 2004) which is actually an average of all the possible split-half reliability estimates of an instrument (Henson 2001). According to Malhotra (2004) Cronbach's alpha coefficient ranges from 0 to 1 and a value of 0.6 or less generally indicates unsatisfactory internal consistency reliability. According to Field (2009:675) Cronbach's alpha level of 0.7 is a suitable cut-off point for reliability test. However, according to Ruperto et al (2005:2856) the internal consistency can be determined with these cutoffs: < 0.6 = poor, 0.6 – 0.64 = slight, 0.65–0.69 = fair, 0.7–0.79 = moderate, 0.8 – 0.89 = substantial and >0.9 = almost perfect. Therefore, in this study Cronbach alphas ($\alpha < 0.6$) were excluded from regression analysis.

3.8. Validity

Validity is the relevance and appropriateness of the information collected to answer the research question. It also indicates the directness and strength of the data collected association with the concepts being researched (Pierce 2008:83). It this regard Factor Analysis (FA) is used to reduce a large number of variables into factors, to establish underlying dimensions between measured variables and latent constructs; and also to provide construct validity evidence of self-reporting scales (Williams et al, 2012:2). FA primary purpose is to attain a more parsimonious conceptual understanding of the set of these measured variables by determining the number and nature of common factors needed to account for the pattern of correlations among them (Fabrigar *et al* 1999:275). Confirmatory factor analysis (CFA) is used to test how well the measured variables represent the number of constructs (Williams et al, 2012:3).Therefore this study conducted CFA on the measures used to examine the dimensionality of the constructs. The total variance explained, scree plots and eigenvalues (equivalent number of variables which the factor represents) were conducted to test the dimensionality.

4. CHAPTER FOUR: PRESENTATION OF RESULTS

4.1. Introduction

This Chapter presents the research results. The study investigated the current state of South African water utility infrastructure with respect to the five performance objectives (cost, dependability, flexibility, quality, and speed) and their trade-offs, and how this relates to its sustainability. The ultimate objective was to develop an operations strategy model to be applied in South African water utilities. Therefore, the results from the data analyses will be presented in section 4. The chapter is organised as follows: presentation of participants by means of descriptive statistics, followed by a description of the measuring instruments and statistical techniques such as correlation analyses, exploratory factor analysis, and the regression analyses to achieve the objectives of the study.

4.2. Section A: Biographical Information

Section 1 of the questionnaire gathered information on biographical information of the responded and was divided into five parts:

- Part I – the gender of the respondents.
- Part II – the age group of the respondents.
- Part III - The highest qualification of the respondents.
- Part IV – The current position of the respondents.
- Part V – The department of the respondents.

4.2.1. The gender of the respondent's distribution

This section aimed at gauging the balance in gender of the respondents in order to test if these responses were not influenced by the gender.

Table 4.1: Gender distribution

	Gender	Frequency	Percent	Cumulative Percent
	Female	19	37	37
	Male	32	63	100.0
	Total	**51**	**100.0**	

The review of table 4.1 shows that there was a relative balance in gender distribution with males at 62.8% and female at 37.3%. This fair representation given the dominance of male in the industry.

4.2.2. The age group of the respondents

This section intended to get a view on the distribution of the respondents' ages to get a sense how different generations view the same challenges differently.

Table 4.2: Age distribution

	Age ranges	Frequency	Percent	Cumulative Percent
Valid	20-25	1	2	2
	26-30	6	12	14
	31-35	13	25	39
	36-40	10	20	59
	41-45	10	20	78
	46-50	2	4	82
	50 and above	9	18	100
	Total	**51**	**100.0**	

According to Table 4.2 age group between 31-35 was a majority with 25%, followed by age group 36-40 and 41-45 at 20% respectively. This was an indication that the sample was dominated by participants with ages from 31 to 45 with a combined value of 65%.

4.2.3. The highest qualification of the respondents

This section intended to get a picture on the distribution of the respondents' highest qualifications to get a sense on the level of education of the respondent making a contribution.

Table 4.3: Qualification distribution

	Qualification	Frequency	Percent	Cumulative Percent
Valid	Certificate	2	4	4
	Degree	15	29	33
	National Diploma	7	14	47
	Post Graduate	27	53	100.0
	Total	**51**	**100.0**	

Table 4.3 suggests that the participants were predominantly post graduates (53%) who were just more than half the total sample. They are followed by degree graduate with 29%. Post graduates combined with degree graduates amounted to 82% of the sample.

4.2.4. The current position of the respondents

The current position for the respondents requested in order to determine the field of respondents that dominated the sample. This assisted the study to have a feel of whether people of relevant occupations answered the questionnaires.

Table 4.4: Positions distribution

Positions	Frequency	Percent	Cumulative Percent
Engineers	11	22	22
Sectional Managers	7	14	35
Project Managers	10	20	55
Area Managers	3	6	61
Operations Managers	4	8	69
Maintenance Managers	3	6	75
Other	13	25	100

Table 4.4 suggests that the sample was dominated by Engineers and Project Managers which made up 42 % of the sample. The 25% in other includes Quantity Surveyors, Project Schedulers and so on which are also predominantly related to Engineers.

4.2.5. The department of the respondents

The department was important for the study because not all departments in the water utilities would make meaningful contribution to this study or understand the questions asked. Most questions were technical because the variables of the study were mainly focused on the technical side of the water utility.

Table 4.5: Departments distribution

Departments	Frequency	Percent	Cumulative Percent
Strategic Asset Management	7	14	14
Capital Projects	22	43	57
Operations and Maintenance	15	29	86
Project Controls	3	6	92
Other	4	8	100

Department distribution as presented in table 4.5 indicates that the sample was dominated by Capital Projects department (43%), operations and maintenance at (29%) and strategic assets (14%) Furthermore, maintenance and operations; and strategic assets management are tasked with the day to day running of the organisation (combined they were 43%).

4.3. Descriptive statistics

Descriptive statistics will focus on mean, standard deviation, Cronbach Apha, skewness and kurtosis. For the mean, the values will be interpreted in-line with the scales of the questionnaire as follows: if the mean value is close to 1 will be considered as strongly disagree, close to 2 will considered as disagree, 3 as neither agree nor disagree, 4 as agree and 5 as strongly agree. The questionnaire had further three sections after Section 1 – and these were Section 2- operations strategy, Section 3 – trade-offs and Section 5 - sustainability. Each section descriptive statistics will be presented in the sections below:

4.3.1. Section 2: Operations strategy closed ended questions

This section of the questionnaire had 24 questions which were divided in five different variables to measure the operations strategy performance objectives. These variables were outlined as follows:

- **Speed:** the following statements measure the speed of water treatment and distribution to the customers by the utility, A01 – A05.
- **Dependability**: the ability of operations to keep the delivery promise to the customers (both internal & external), A06 – A10.

- **Flexibility**: the ability of the utility's operations to change water volumes, A11 – A14.
- **Quality**: level of conformance to specifications and critical customer water expectations, A15 – A19.
- **Cost**: measures of the amount of resources used by the utility's operations to produce the water, A20 – A24.

Table 4.6: operations strategy descriptive statistics

No.1	Mean	Std. Deviation	Skewness	Kurtosis	Cronbach's Apha	Factor Loading
Speed						
A01	.568	0.8843	-2.485	7.666	0.518	0.568
A02	.582	1.3516	-0.388	-1.241	0.604	0.582
A03	.528	1.1265	-0.787	-.118	0.593	0.528
A04	.800	0.8340	-1.183	1.839	0.591	0.800
A05	.689	0.9485	-1.193	1.520	0.466	0.689
Overall	**3.764**	**0.6536**	**-.666**	**1.101**	**0.554**	
Dependability						
A06	4.060	1.0956	-1.481	1.925	0.409	0.614
A07	3.820	1.0631	-.899	0.015	0.422	0.578
A08	2.320	.9781	.939	0.278	0.326	0.720
A09	3.900	1.0738	-1.648	2.484	0.429	0.529
A10	3.360	1.0835	-.576	-0.447	0.491	0.380
Overall	**3.492**	**0.6010**	**-0.248**	**-0.662**	**0.415**	
Flexibility						
A11	3.380	1.047	-0.056	-1.240	0.644	0.655
A12	3.940	0.912	-1.220	1.781	0.454	0.855
A13	3.740	0.852	-0.903	0.340	0.578	0.733
A14	3.880	0.824	-0.681	0.333	0.675	0.575
Overall	**3.7350**	**0.64367**	**-0.574**	**0.532**	**0.588**	
Quality						
A15	4.280	0.6402	-0.808	1.946	0.654	0.574
A16	3.740	0.8762	-0.973	1.249	0.649	0.603
A17	4.060	0.8430	-0.968	0.863	0.589	0.717
A18	4.320	0.7407	-1.227	2.094	0.649	0.613
A19	4.180	0.7475	-0.920	1.287	0.561	0.784
Overall	**4.116**	**0.5096**	**-0.663**	**1.263**	**0.620**	
Cost						
A20	3.540	0.9082	-0.464	0.175	0.744	0.713
A21	3.480	0.9947	-0.072	-0.442	0.799	0.538
A22	3.600	0.8330	-0.441	-0.276	0.761	0.679
A23	3.260	1.0654	-0.760	-0.020	0.665	0.878
A24	3.520	1.0736	-0.775	0.082	0.709	0.820
Overall	**3.480**	**0.7149**	**-0.166**	**-0.694**	**0.736**	

According to table 4.6 the mean for the speed which is the measure of water treatment and distribution by the water utility to the customers is 3.76 (leans more to agree). Dependability, which is the ability of the utility's operations to keep the delivery promises to the customers (both internal & external) has a mean of 3.49 (leans more toward neither agrees nor disagrees). Flexibility has a mean of 3.74 (leans more towards agree). Quality has a mean of 4.12 (agree). Quality in this instance was looking at the level of conformance to specifications and critical customer water expectations by the water utility is 4.12 which an agree. Cost has a mean of 3.48 (leans more towards neither agree or disagree). Overall operations strategy has a mean of 3.72 (leans more towards agree).

Table 4.6 also presents the results for the reliability performance of the measuring instruments. The internal consistency reliability was assessed by the use of Cronbach's alpha and the values that were obtained ranged from 0.415 to 0.736. Field (2009:675) suggests that Cronbach's alpha level of 0.7 is generally a suitable cut-off point for reliability test. Cost had a Cronbach's alpha rounded off to 0.7; flexibility, speed and quality were rounded off to 0.6 which below 7 but some scholars do take 0.6 as an acceptable value; therefore, this value will be adopted as acceptable in this study. Dependability was low at 0.5 rounded off, this suggest that the respondents' response to the items (A6-A10) were not consistent. This might be attributed to the possibility that most participants might not have been familiar with the concept of dependability, subsequently were not too sure above how to answer. Overall, the measuring instruments for operations strategy will be adopted as reliable.

Furthermore, Table 4.6 also presents Skewness and Kurtosis values for the operations strategy performance objectives matrix. The rule of thumb for skewness suggest that the values less than -1 or greater than 1, imply that the distribution is highly skewed, and values between (-1 and -0.5) or between (0.5 and 1), imply that the distribution is moderately skewed, values between (-0.5 and 0.5), imply that the distribution is approximately symmetric. All the variables were negatively skewed. The distribution for speed, flexibility and quality was moderately skewed, while dependability and cost had an approximately symmetric distribution. On the other hand, the kurtosis for speed, flexibility and quality were positive, while dependability and cost were negative. Therefore, this means there would be no reason to suspect that the distribution of the construct is not normal.

4.3.2. Section 3: Trade-offs closed ended questions and matrix

This section consisted of of five closed ended questions B1-B5 and five questions for ranking according to imporatnace B6-B10. Table 4.7 below presents the descriptive statistics data for trade-offs which are mean, standard deviation, Cronbach's alpha, skewness and kurtosis, while table 4.8 presents the results on how the performance objectives were ranked.

Table 4.7: Trade-offs descriptive statistics

	Mean	Std. Deviation	Skewness	Kurtosis	Cronbach's Apha	Factor Loading
B1	3.800	1.0880	-0.971	0.346	0.687	0.756
B2	2.800	1.2778	0.208	-1.366	0.718	0.702
B3	3.360	1.1021	-0.581	-0.573	0.686	0.773
B4	3.520	1.0925	-0.591	-0.458	0.701	0.733
B5	3.500	1.1650	-0.928	0.040	0.751	0.590
Trade-offs	**3.396**	**0.8136**	**-0.303**	**-0.320**	**0.753**	

The mean for trade-offs is 3.40 (more towards neither agree or disagree). This indicates that the participants were not sure about whether to trade-off other activities to focus more on operation. The skewness and kurtosis were -.303 and -.320 respectively. This suggests that they both have approximately symmetric distributions.

Table 4.8: Result of operations strategy performance objectives ranking

Performance objectives	1	2	3	4	5
Quality of water produced and supplied	31	10	0	5	5
Cost of treating and supplying water to customers.	2	13	12	14	9
Speed of water purification and supply	5	7	21	9	8
Flexibility of water production volumes and delivery process.	4	6	12	16	

According to Table 4.8, quality of water produced by water utility and supplied to the customers is ranked number one in terms of importance. 61% believed that quality is number one in importance. Cost was ranked in second place by 25% participants; speed was ranked in third place by 41% of participants and flexibility was ranked in fourth place by 31% of participants.

4.3.3. Section 4: Sustainability closed ended questions and matrix

This section of the questionnaire had 10 closed ended questions and it was divided into two sections that were used to measure sustainability as follows:

- **Maintenance** - status of the current infrastructure plans of the organisation, D1 –D5.
- **Capital expansion** - status of the current capital expansion plans of the organisation, D6 –D10.

Table 4.9: sustainability discriptive statistics

	Mean	Std. Deviation	Skewness	Kurtosis	Cronbach's Apha	Factor Loading
Maintenance						
D1	3.300	1.2495	-0.340	-1.104	0.735	0.814
D2	3.340	1.1359	-0.369	-1.044	0.779	0.673
D3	3.300	1.0351	0.046	-1.236	0.727	0.828
D4	3.120	1.0428	0.089	-1.103	0.744	0.785
D5	3.400	1.1249	-0.412	-0.868	0.796	0.613
Overall	3.292	0.8312	-0.175	-1.006	0.796	0.814
Capital Expansion						
D6	3.900	0.7626	-0.690	0.730	0.854	0.787
D7	3.260	1.1920	-0.379	-0.954	0.849	0.803
D8	3.340	1.1537	-0.464	-0.867	0.847	0.806
D9	3.820	0.8734	-1.357	2.082	0.841	0.825
D10	3.700	1.0546	-0.881	0.291	0.818	0.876
Overall	3.604	0.8276	-0.767	0.330	0.870	

The mean for current status of maintenance is 3.292 (leans more towards neither agree or disagree) and for capital expansion programme is 3.604 (leans more towards agree). Cronbach's alphas are 0.8 for maintenance and 0.9 for capital expansion which suggest that the sub-scales for these items were reliable. The skewness and kurtosis for maintenance and capital expansion were -.175 and -1.006; and -.767 and .330 respectively.

4.4. Correlations

This section focuses on the correlations between the variables covered in the study i.e. operations strategy performance, trade-offs and sustainability. The correlations were done as part of achieving some of the objectives of the study which was to develop a model. In order to achieve this, it was important to test the correlation between the independent variable, dependent variable and mediating variable. Table 4.10 does not include dependability because it had a Cronbach's alpha value below a 0.6 cut-off and so it was dropped.

Table 4.10: Correlations

		Speed	Flexib.	Quality	Cost	Trade-Off	Maintenance	Capital Exp.
Speed	**Pearson Correlation**	1						
	Sig. (2-tailed)							
Flexibility	**Pearson Correlation**	.384**	1					
	Sig. (2-tailed)	.006						
Quality	**Pearson Correlation**	-.061	.288*	1				
	Sig. (2-tailed)	.675	.042					
Cost	**Pearson Correlation**	.333*	.553**	.189	1			
	Sig. (2-tailed)	.000	.000	.001				
Trade-Off	**Pearson Correlation**	.301*	.150	-.209	.102	1		
	Sig. (2-tailed)	.034	.299	.144	.483			
Maintenance	**Pearson Correlation**	.302*	.439**	.215	.575**	.002	1	
	Sig. (2-tailed)	.033	.001	.133	.000	.990		
Capital Expansion	**Pearson Correlation**	.387**	.634**	.223	.611**	-.017	.618**	1
	Sig. (2-tailed)	.006	.000	.088	.000	.907	.000	

** Correlation is significant at the 0.01 level / *. Correlation is significant at the 0.05 level, p = 0.1 the effect size is small, p = 0.3 the effect size is medium and p = 0.5 is large effect size.

Speed has a positive significant correlation (medium effect size) with flexibility, a negative insignificant correlation (small effect) with quality, a positive significant correlation (medium effect size) with cost, a positive significant correlation (medium effect size) with trade-offs, a positive significant correlation (medium effect size) with maintenance and a positive significant correlation (medium effect size) with capital expansion.

Flexibility has a positive significant correlation (medium effect size) with quality, a positive significant correlation (large effect size) with cost, a positive insignificant correlation (small effect size) with trade-offs, a positive significant correlation (medium effect size) with maintenance and a positive significant correlation (large effect size) with capital expansion.

Quality has a positive significant correlation (small effect size) with cost, a negatively insignificant correlation (small effect size) with trade-offs, a positive insignificant correlation (small effect size) with maintenance and a positive insignificant correlation (small effect size) with capital expansion.

Cost has a positive insignificant correlation (small effect size) with trade -offs, a positive significant correlation (large effect size) with maintenance and a positive significant correlation (large effect size) with capital expansion.

Trade-offs has a positive insignificant correlation (small effect size) with maintenance and a negatively insignificant correlation (small effect size) with capital expansion.

Capital expansion has a positive significant correlation (large effect size) with maintenance.

4.5. Validity of the Measuring Instrument

In order to ensure validity each construct was tested to determine the percentage of variance explained by single factor. Williams *et* al, (2012:3) suggest that confirmatory factor analysis should be used to test how well the measured variables represent the number of constructs. Therefore, this study conducted confirmatory factor analysis to establish the structure of the relationship between the studied variable for all three variables depended (sustainability), independent (operations strategy) and mediating (trade-offs).

Bartlett's test was conducted to check whether the data meet the minimum requirement for conducting the factor analysis. According to Yong and Pearce (2013:88) KMO cut-off for sampling adequacy is 0.50. Therefore, for this study any value from 0.5 and above is considered as acceptable. Table 4.11 provides the values for KMO obtained for the variables.

Table 4.11: Bartlett's test of Sphericity

Variable	KMO	Approx. Chi-Square
Speed	0.600	36.031
Flexibility	0.615	35.663
Quality	0.667	42.058
Cost	0.684	86.685
Trade-offs	0.732	56.914
Maintenance	0.714	82.564
Capital Expansion	0.863	114.631

From the results in table 4.11 capital expansion KMO value is above 0.8 and all the other 7 variables have the KMO value ranging from 0.6 to 0.7. Given that they are all above 0.5 means that the sampling was also good enough for the purpose of the study. Therefore, this data is suitable to conduct factor analysis. Table 4.12 therefore presents the results on confirmatory analysis for all the variables where percentage variance explained are indicated for each variable.

Table 4.12: Confirmatory Factor Analysis results

	Extraction Sums of Squared Loadings	
Component	**Total**	**% of Variance**
Speed	2.055	41.099
Flexibility	2.028	50.693
Quality	2.198	43.969
Cost	2.702	54.047
Trade-off	2.548	50.960
Maintenance	2.793	55.860
Capital Expansion	3.361	67.223

Inspection of Table 4.12 suggests that the total variance explained for in almost all the items are above 40% therefore, the factor structure is confirmed as Stacciarini and Pace (2017) on their study recommended variance explained as low as 34%.

4.6. Regression Analysis

This study used regression analysis to test the strength and direction of the relationship between operations strategy, sustainability and trade-offs. The objective was to establish whether the relationship is according to the hypothesised model. The analysis of variance (ANOVA) test was ran for three paths namely, operations strategy predicting sustainability, operations strategy predicting trade-offs and trade-offs predicting sustainability. Furthermore, Coefficients tables were used to predict these variables, as well as to determine whether there was a statistical significance to the model.

The subsections following present the regression analysis on operation strategy predicting trade-offs, operations strategy and trade-offs predicting sustainability and trade-offs predicting sustainability. Each subsection has a model summary where R-square provides the goodness of fit for each model. The next will be ANOVA that will provide information the model's independent variable predicting dependent variable. The last will be coefficients which provide information on significance level for accepting or rejecting the null hypothesis. As a rule of thumb the significance level for this study will be 0.05 and when the p-value is less than or equal to the significance level the null hypothesis is rejected.

4.6.1. Operations strategy on predicting trade-offs

Table 4.13: model summary, anova and coefficients for operations strategy vs trade-offs

<table>
<tr><th colspan="7">Model Summary</th></tr>
<tr><th>Model</th><th>R</th><th>R Square</th><th colspan="2">Adjusted R Square</th><th colspan="2">Std. Error of the Estimate</th></tr>
<tr><td>1</td><td>.147[a]</td><td>0.022</td><td colspan="2">0.001</td><td colspan="2">0.8132</td></tr>
<tr><th colspan="7">ANOVA[a]</th></tr>
<tr><th colspan="2">Model</th><th>Sum of Squares</th><th>df</th><th>Mean Square</th><th>F</th><th>Sig.</th></tr>
<tr><td rowspan="3">1</td><td>Regression</td><td>0.698</td><td>1</td><td>0.698</td><td>1.056</td><td>.309[b]</td></tr>
<tr><td>Residual</td><td>31.741</td><td>48</td><td>0.661</td><td></td><td></td></tr>
<tr><td>Total</td><td>32.439</td><td>49</td><td></td><td></td><td></td></tr>
<tr><th colspan="7">Coefficients[a]</th></tr>
<tr><th colspan="2" rowspan="2">Model</th><th colspan="2">Unstandardized Coefficients</th><th>Standardized Coefficients</th><th rowspan="2">t</th><th rowspan="2">Sig.</th></tr>
<tr><th>B</th><th>Std. Error</th><th>Beta</th></tr>
<tr><td rowspan="2">1</td><td>(Constant)</td><td>2.386</td><td>0.99</td><td></td><td>2.41</td><td>0.02</td></tr>
<tr><td>OPO</td><td>0.272</td><td>0.265</td><td>0.147</td><td>1.028</td><td>0.309</td></tr>
</table>

R-square for this model is 0.022, which means that the operations strategy variable can explain about 2.2% of the change in trade-offs. The significance level is 0.309 which is greater than 0.05 which suggest that null hypothesis that operations strategy does not predict trade-offs can be accepted.

4.6.2. Operations strategy and trade-offs on predicting sustainability

Table 4.14: model summary, anova and coefficients for operations strategy and trade-offs vs sustainability

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.752[a]	0.565	0.547	0.5021

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	15.416	2	7.708	30.577	.000[b]
	Residual	11.848	47	0.252		
	Total	27.265	49			

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	-0.978	0.647		-1.511	0.137
	OPO	1.291	0.165	0.76	7.82	0.00
	Trade-Off	-0.11	0.089	-0.12	-1.234	0.223

R-square for this model is 0.565, which means that the operations strategy and trade-offs can explain about 56.5% of the change in sustainability. The significance levels are 0.00 and 0.223 for operations strategy and trade-offs respectively. The operations strategy significance level is less than 0.05 and the trade-offs one is greater than 0.05. This suggests that the null hypothesis that operations strategy does not predict sustainability can be rejected, while null hypothesis that trade-offs do not predict sustainability can be accepted.

4.6.3. Trade-offs on predicting sustainability

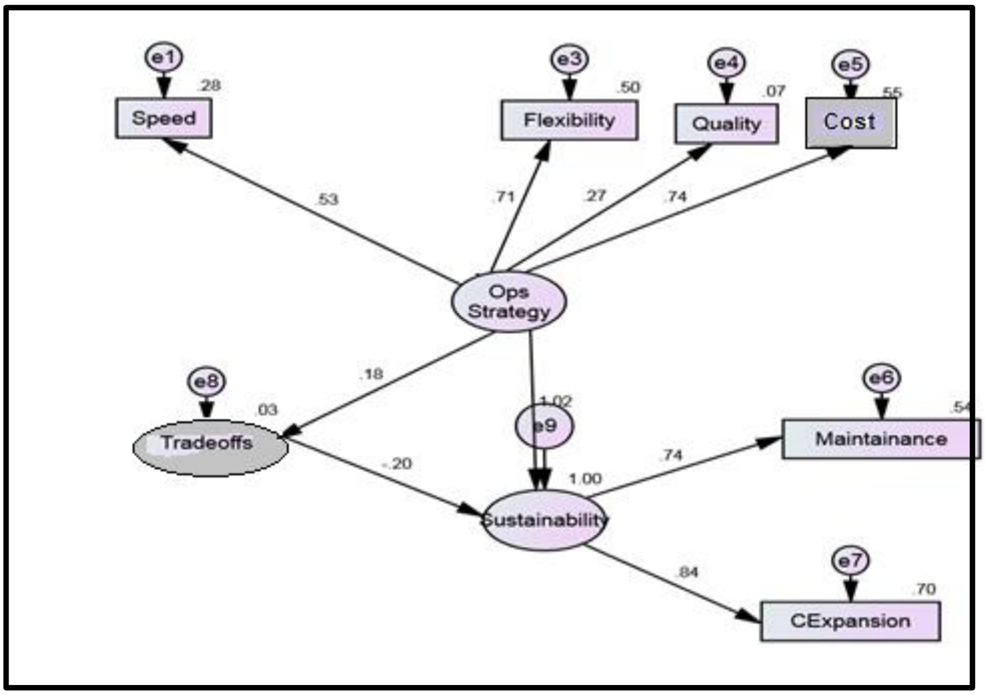
Table 4.15: model summary, anova and coefficients for trade-offs vs sustainability

Model Summary						
Model		**R**	**R Square**	**Adjusted R Square**		**Std. Error of the Estimate**
1		.008[a]	0.00	-0.021		0.7536
ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	0.002	1	0.002	0.003	.954[b]
	Residual	27.263	48	0.568		
	Total	27.265	49			
Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	3.474	0.462		7.523	0
	Trade-Off	-0.008	0.132	-0.008	-0.058	0.954

Table 4.15 present that R-square for this model is 0.00, which means that trade-offs can explain about 0 % of the change in sustainability. The significance is 0.954 which is greater than 0.05 so the null hypothesis is accepted therefore the model has predictive value.

4.7. The mediating effects and Structural Equation Model

Structural Equation Modelling was performed using AMOS 20 for testing for mediating effects of trade-offs in the relationship between operations strategy performance objectives and water utility sustainability. The model in figure 4.1 resulted.



<u>Figure 4.1</u>: Model resulted from the SEM analysis

A good fit for the proposed hypothetical model was obtained (see Figure 4.1 $\chi2$ (18, N = 51) = 23.35, p = 0.18; $\chi2$/df = 1.3, the Tucker Lewis index (TLI) = 0.94, the comparative fit index (CFI) = 0.96 and the root mean square error of approximation (RMSEA) was 0.08.

4.7.1. Direct, Indirect and Total Standardized Effects

In order to test the mediation, the Beta-values for the standardized direct, indirect, and total were calculated. When analysing the mediator, there are two effects involved namely direct effect and indirect effect. The direct effect is the effect from the independent variable directly to a dependent variable, while the indirect effect is the effect from independent variable to a dependent variable that goes indirectly through the mediating variable. According to Zhao *et* al (2010) in order to establish mediation, the indirect effect should be greater than the direct effect. However, for this study indirect effect (a relationship between operation strategy performance and sustainability via trade-offs) is -0.04 = (0.18) x (-0.20) while direct effect (a relationship between operation strategy performance and sustainability without trade-offs) is 1.02.

4.7.2. Hypothesis Testing: required to determine the mediation effect

This study had three hypotheses in-line with figure 2.8 as they are highlighted in table 4.16 below. Multi-regression was conducted to test these hypotheses and the results are furnished in table 4.13 to 4.15.

Table 4.16: the hypothesis testing for a direct effect of operations strategy on sustainability

Hypothesis statement for path analysis	Beta Estimate	P-Value
H1: operation strategy performance has a significant and direct effect on water utility sustainability (***P $\leq$ 0.001)	1.17	***
H2: operation strategy performance has a significant and direct effect on trade-offs	0.28	0.25
H3: trade-offs have a significant and direct effect on water utility sustainability	-0.15	0.07

Inspection of table 4.16 suggests that p-values for both H2 and H3 are greater than 0.05 which means their direct paths are insignificant.

4.8. Results Summary and Conclusion

The main findings of the investigation are summarised in sub-sections below. The more in-depth discussion of the results is covered in Chapter 5.

4.8.1. Biographical Information

The respondents were 37% female and 63% male. Age group was predominantly 31 to 45 which made up to 76%. Highest qualification was predominantly degreed and post graduates with a combined total of 82%. Respondents were most of the engineering background with about a minimum of 67% with engineering background. About 43% were from capital expansions department and 29% from operations and maintenance.

4.8.2. Descriptive statistics

Speed had a mean =3.764, Cronbach's Alpha =0.554 and factor loading ranging from 0.568 to 0.800. Dependability had a mean =3.492, Cronbach's Alpha =0.415 and factor loading ranging from 0.0.380 to 0.720. Flexibility had a mean =3.7350, Cronbach's Alpha =0.588 and factor loading ranging from 0.575 to 0.855. Quality had a mean =4.116, Cronbach's Alpha =0.620 and factor loading ranging from 0.574 to 0.717. Cost had a mean =3.840, Cronbach's Alpha =0.736 and factor loading ranging from 0.538 to 0.878. Trade-offs had a mean =3.396, Cronbach's Alpha =0.753 and factor loading ranging from 0.590 to 0.773. Maintenance had a mean =3.292, Cronbach's Alpha =0.796 and factor loading ranging from 0.613 to 0.828. Capital Expansion had a mean =3.604, Cronbach's Alpha =0.870 and factor loading ranging from 0.783 to 0.876.

4.8.3. Correlations

The Correlations were computed among all nine items of the variables studied which were operations strategy, trade-offs and sustainability. Regarding the significant correlations found

Speed had a positive significant correlation with all variables except quality. Quality had a positive significant correlation with cost. Cost had positive significant correlation with maintenance and capital expansion. Trade-offs has no significant correlation with any other variable. Capital expansion had a positive significant correlation with maintenance.

4.8.4. Validity of the Measuring Instrument

Capital expansion KMO value was 0.863 and all the other 7 variables have the KMO value ranging from 0.600 to 0.732. The variance explained from Confirmatory Factor Analysis ranged from 41.099 to 67.223.

4.8.5. Regression Analysis

Operation strategy on trade-offs R-square was 0.022 and p-value of 0.309. Operation strategy and trade-offs on sustainability R-square was 0.565 and p-values of 0.000 and 0.223 respectively

4.8.6. The mediating effects and Structural Equation Model

A good fit for the proposed hypothetical model was obtained with the following parameters:

- $\chi 2$ (18, N = 51) = 23.35
- p = 0.18
- $\chi 2$/df = 1.3
- TLI = 0.94
- CFI = 0.96
- RMSEA =0.08

Hypothesis results were as follow:

- H_1 – beta =1.17 and p-value < 0.001
- H_2-beta =0.58 and p-value =0.250
- H_3 – beta = -0.15 and p-value = 0.07

In conclusion, this chapter presented the research data analysis that was gathered through a questionnaire and analysed using various statistical methods. The purpose of this study was to examine the current state of South African water utilities infrastructure with respect to the five performance objectives and their trade-offs, and how this relates to its sustainability.

5. CHAPTER 5: DISCUSION OF RESEARCH FINDINGS

The fundamental problem that the study was investigating was the assessment of the current status of South African water utility infrastructure in relation to the operations strategy performance objectives and determining the trade-offs thereof. The goal was to identify the most appropriate performance objectives to focus on for effective service delivery that the utility should expend its limited resources on in the current challenging economic circumstances. This problem was investigated by answering the research question, set of objectives and testing of the hypothesised model and the resulting answers are discussed on the section below.

5.1. Research Question

In the beginning the study has posed the question “what is a better option for the South African water utilities, to focus on all five generic operations strategy performance objectives or to trade-off some of them”. This was a broad question of which set of objectives were set to provide a simplified approach in answering this questions. The answer to the research question was that the water utilities should prioritise water quality more than any other performance objective (refer to table 4.8 - performance objectives ranking).

This finding is in-line with the findings of Sustainability Accounting Standards Board (2017:20) which suggest that water quality is of number one importance. They suggest that low quality water may result in increased operating costs or capital expenditures and reputational risk. Quality was followed by the cost of water in second position and speed of water processing and delivery in third position. As highlighted in the introduction that water is a basic human right as prescribed the South African constitution, having quality and cost ranked as the top two. Therefore, this suggests that if the water utilities were to trade-off some of the performance objectives, flexibility and dependability would be the performance objectives to be sacrificed.

5.2. Research Objectives

As alluded in section 5.1, in order to address the research question there were research objectives that were set out to guide the study. In summary the

Objective number 1: To characterise the main activities of a water utility in terms of operations strategy matrix, in particular performance objectives (cost, dependability, flexibility, quality and speed).

The primary goal of this objective was to gather the preliminary knowledge in order to develop the hypothetical model to guide the study. This objective was achieved through qualitative preliminary study that was conducted within one of South African water utilities by engaging experienced people in operations. The aim was to be able to properly characterised the operations strategy elements in order to develop the hypothesised model (refer to figure 2.8 for the hypothesised model).

Objective number 2: To assess the extent of importance of each of the five generic operations performance objectives namely cost, dependability, flexibility, speed and quality in South African water utilities.

This objective was achieved by the use of questionnaire with close ended questions that had 24 questions with an average of five questions per performance objective (refer to annexure 1 - the full questionnaire). The mean for each performance objectives was 3.76 for speed which is leaning more towards the scale of 4 which is agree. This suggests that on average respondents agree that the speed of processing and delivery is important. Flexibility has an average of 3.74 which leans more towards the scale of 4 which means that respondents agree that the flexibility in water utility operations is important. As also indicated in the research question and in table 4.8 when quality was raked 1 in terms of most important performance variable, quality has a rating of 4.12 leans more towards agree but moving towards strongly agree that the water quality is important in water utility operations strategy. Cost is surprisingly having a mean of 3.48 which leans more towards neither agree nor disagree. It would have been expected that it should have a mean leaning towards agree.

Objective number 3: To determine the current state of infrastructure and infrastructure capital expansion plans.

This objective was ascertained through the use of a questionnaire with ten close ended questions questionnaire. On average in terms of the respondents' level of agreement with regard to their importance, the mean of 3.29 for maintenance plans execution; 3.60 for capital expansions plans execution and 3.45 for overall sustainability importance of the water utility were obtained (refer to table 4.9). There is some level of uncertainty indicated by respondents on this element in general.

Objective number 4: To develop a trade-offs model for operations strategy in a water utility in South Africa.

This was linked with the three hypotheses that were developed from the hypothesised model. The model hypothesised had operations strategy as an independent variable, trade-offs as a mediating variable and sustainability as a dependent variable. Various tests were conducted in order to achieve this objective such as correlation analysis. The correlations (refer to table 4.10) for these variables had various statistical significance and size.

Amos was used to conduct Structural Equation Modelling and the following results were found, namely a good fit for the proposed hypothetical model was obtained (see Figure 4.1) χ^2 (18, N = 51) = 23.35, p = 0.18; χ^2/df = 1.3 which is within the recommended value of $\leq$ 3.00, the Tucker Lewis index (TLI) = 0.94 which is within the recommended $\geq$ .90, the Comparative Fit Index (CFI) = 0.96 is within the recommended $\geq$ .95, and the Root Mean Square Error of Approximation (RMSEA) was 0.08 which is acceptable given that the recommended is $\leq$ .08 and $\leq$ .05 is excellent. The recommended figures for SEM model were adopted from Yuan and Chan (2016). Therefore, the finally recommended model can be trusted and can be used. However, the final model will be modified and recommended based on the results of hypothesis testing.

5.3. Validity of Measuring Instrument

The validity of the measuring instrument was tested by using Confirmatory Factor Analysis (refer to section 4.5). Bartlett's test of Sphericity was conducted to test the adequacy of the sample to conduct factor analysis (refer to section 4.5). All the KMO values were found to be above 0.5 (refer to table 4.11) which gave the go-ahead to conduct factor analysis. As presented by table 4.12 the total variance explained for in almost all the items is above 40%; therefore, the factor structure is confirmed. These results are consistent with Stacciarini and Pace (2017) study that recommended variance explained for can be as low as 34%.

5.4. Hypothesis

This study had three hypotheses that were derived from the hypothesised model presented in figure 2.8 and these hypotheses are presented in section 4.7.2 This study used regression analysis to estimate the strength and direction of the relationship between operations strategy, sustainability and trade-offs. The objective was to establish whether the relationship is according to the hypothesised model. The analysis of variance (ANOVA) test was run for three paths namely, operations strategy predicting sustainability, operations strategy predicting trade-offs and trade-offs predicting sustainability. Furthermore, Coefficients tables were used to predict these variables, as well as to determine whether there was a statistical significance to the model (refer to tables 4.13 to 4.15).

There were three null hypotheses that were tested using regression analyses and they were:

- H_{01} - Operations strategy do not predict trade-offs.
- H_{02} - Operations strategy and trade-offs do not predict sustainability.
- H_{03}- Trade-offs do not predict sustainability.

H_{01} results indicates that the percentage of operations strategy explaining the change in trade-offs of 2.2% is significantly low and the very high significance level of 0.309 suggest that the null hypothesis was significantly supported. These results therefore mean that the study has failed to prove the hypothesis that operation strategy performance has a significant effect on trade-offs.

H_{02} results have found that operations strategy and trade-offs can explain about 56.5% of the change in sustainability which is reasonable high, with very high significance level 0.00 and low significant level of 0.223 for operations strategy and trade-offs respectively. Therefore, these results suggest that only operations strategy predicts sustainability and the trade-offs do not.

H_{03} trade-offs can explain about 0.00 % of the change in sustainability which is significantly low and the very low significance level of 0.954 which p-value is far greater than 0.05 suggests no predictive value.

There were three hypotheses that were tested using multi-regression analyses and they were (refer to table 4.16):

- H1: operation strategy performance has a significant and direct effect on water utility sustainability.
- H2: operation strategy performance has a significant and direct effect on trade-offs.
- H3: trade-offs have a significant and direct effect on water utility sustainability.

H_1 has a Beta of 1.17 and p value of far less than 0.001 which means that the hypothesis is supported. Therefore, these results suggest that water utilities in South Africa should note that their operations strategy can affect their sustainability. H_2 and H_3 have a Beta value of 0.28 and -0.15; and p values of 0.250 and 0.07 respectively (refer to table 4.16). These results do not support the hypotheses and therefore the model was modified to only include the supported hypothesis. The results are also consistent with the ANOVA results in section 4.6 where the two null hypotheses were supported and only the null hypothesis on operations strategy not predicting sustainability was rejected. Therefore, these results can be trusted and the final model recommended can also be trusted.

5.5. Study Final Model

A hypothesised model of the relationship between operations strategy performance, trade-offs, and water utility sustainability was tested in a convenience sample (n = 51), and respondents were recruited from a number of departments in some of the South African water utilities. The data did not support the model as it was hypothesised. However, when the mediating variable (trade-offs) was removed (table 5.1), the new model was supported by the data. The utility operations strategy performance influences their sustainability. Therefore, based on table 5.1 the model in figure 5.2 is the model that is proposed for the South African water utilities going forward.

Table 5.1: Standardized Direct Effects without trade-offs

Variables	Operations Strategy performance	Sustainability
Sustainability	1.02	0.00
Capital Expansion	0.00	0.84
Maintenance	0.00	0.74
Speed	0.53	0.00
Flexibility	0.71	0.00
Quality	0.27	0.00
Cost	0.74	0.00

Table 5.1 suggest that operation strategy performance has a significant and direct effect on water utility sustainability (***$P \leq 0.001$ and $r = 1.02$). This relationship resulted in a model presented in figure 5.2.

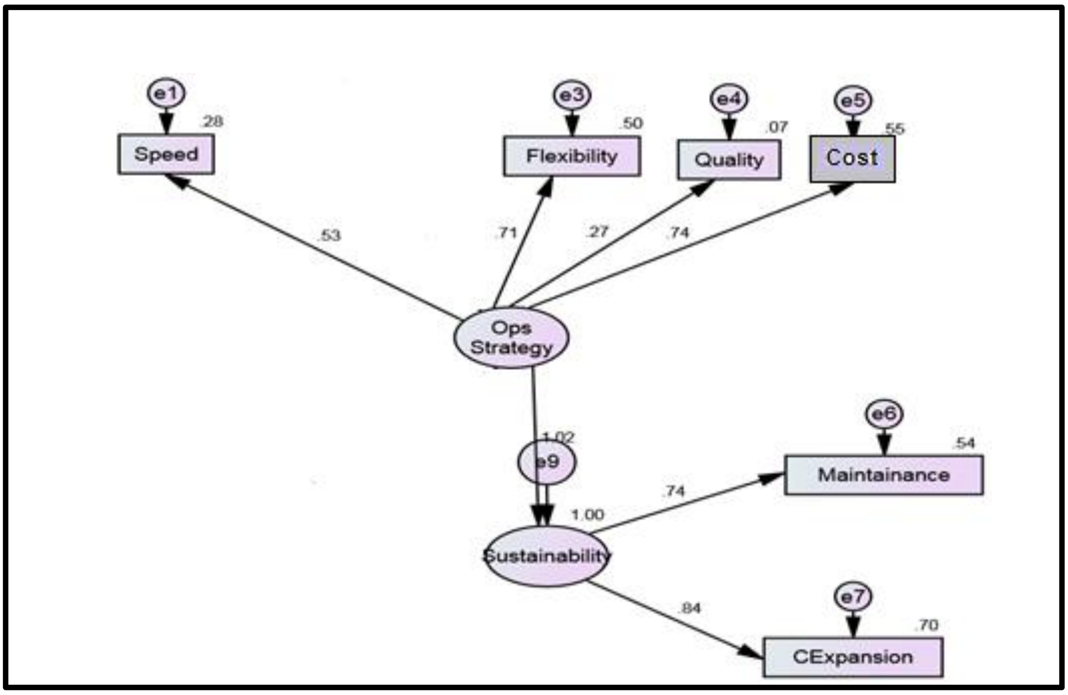


Figure 5.1 Water utility model

The model in figure 5.2 suggests that if the water utilities achieve robust operations strategy by good management of five operations strategy performance objectives while maintaining their plants well and managing their capital expansions, they will have sustainable utilities. The major limitation of this study was the sample size especially given that the new model was to be developed. Furthermore, given the complexity of the model in a sense that it contained the mediating variable, a big sample size would have been ideal. The study was conducted predominantly using some sections of a specific water utility using a convenience sample and other water utilities were difficult to gather data from.

The literature has proven beyond reasonable doubt that trade-offs are important in operations of any organisation. For instance, the studies that were conducted by Rosenzweig & Easton (2010:134-35) and Dzombak & Dornfeld (2015:3) assert that in any manufacturing industry the trade-offs are key for competitiveness. Therefore, even though the study has failed to prove that the trade-offs play a mediating role in the relationship between operations strategy and sustainability of the South African water utilities, the study has nevertheless shown that the operations strategy has significant role to play in the sustainability of the South African water utilities. There are a couple of inferences that can be drawn from this study.

For instance, it was evident that the water utilities need to put more focus on their quality. This was not a surprise because quality talks to the people's health and talks to the product itself. If the water quality is not up to standard it would undermine the entire operation of the water utility and also violate people's constitutional right of access to clean water. Furthermore, if the operations strategy does not support the sustainability plans of the utility, then the utility would be as good as not existing. Therefore, the model that the study has developed should go a long way in improving the sustainability of water utilities, consequently this would contribute to economic growth of the country. This model would assist the country to realise their section 27 of the Bill of Rights of the Constitution, in particular access to clean water.

Some findings of this study are in-line with previous study findings. For instance, Slack (2002:961) in his "exploring the trade-off concept" study concluded that trade-offs in the organisation exist and are central on how managers execute their operations strategies. Flynn *et* al (1999:265) using Hayes and Wheelwright model found that operations strategy is strongly related to competitive performance.

In reflecting on short comings of the study the participants of this study were predominantly from one of the biggest water utilities in the country rather than the spread out to several others and therefore the sample could have been bigger especial for purposes of testing a brand new model. Furthermore, the phenomenon of trade-offs in operations strategy in South Africa is not necessary one that is well understood, which might have contributed to some inconsistent responses from participants on trade-offs related question.

In conclusion this chapter deliberated on the results obtained from analysis of the data from participants and makes reference to the relevant literature review. The main findings of the study are summarised in each section and overall findings are summarised in section 5.5 which also presents the final model of the study. The next Chapter 6 concludes the study, including mentioning the study limitations and making recommendations for water utilities, recommendations for further research are also given.

6. CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

This chapter provides the conclusions and the recommendations of the study to the utilities and for further studies.

6.2. Conclusion

The primary drive for undertaking the study has been that water utility infrastructure is aging while the demand is increasing. There are many competing variables to be considered towards sustaining the utilities such as cost, quality, flexibility among others. The study examined the relationship between the water utility's operations strategy, and sustainability and also examined the mediating role of trade-offs between operations strategy and sustainability.

All the study objectives were met. For instance, objective number 1 of characterising the main activities of a water utility in terms of operations strategy matrix, in particular performance objectives (cost, dependability, flexibility, quality and speed) was achieved through engaging experience employees of water utilities and literature. The result of this objective formed the foundation of the questionnaire development.

Objective number 2 which was to assess the extent of importance of each of the five generic operations performance objectives namely cost dependability, flexibility, speed and quality in South African water utilities was achieved by assessing the mean and other descriptive statistics as outlined in section 5.2. The result indicate that these variables are important in the water utility.

Objective number 3 which was to determine the current state of infrastructure maintenance and infrastructure capital expansion plans was achieved by assessing the mean and other descriptive statistics as outlined in section 5.2. Objective number 4 which was to determine which of the five generic operations performance objectives rank higher than others for a water utility was achieve (refer to table 4.8) where quality was ranked number 1 as the most important performance objective.

Objective number 5 which was to develop a trade-offs model for operations strategy in a water utility in South Africa was met as the new model was developed (refer to figure 5.2 for final model).

The study research question which states what is a better option for the South African water utilities, to focus on all five generic operations strategy performance objectives or to trade-off some of them? Was also answered as table 4.8 indicate that the top 3 most important performance objectives are quality, cost and speed. This suggest that the utilities can chose to trade-off the other two performance objectives which are flexibility and dependability.

This study is significant in that it adds the operations strategy model that can be used in South African water utility industry. No other study has been initiated in the literature which has looked at operations strategy in the context of performance objectives in water utilities and which has defined sustainability of water utilities in terms of capital expansion and maintenance. This study can therefore claim to have initiated the closure of this gap.

6.3. Limitations of the study

The major limitation for this study was the small sample size especially given that the new model was going to be developed and needed to be tested. Furthermore, given the complexity of the model in a sense that it contained the mediating variable a big sample size would have been ideal. Ultimately, the study was conducted predominantly using some sections of a specific water utility using a convenience sample and other water utilities were difficult to gather the data from.

6.4. Recommendations

This section provides recommendations to water utilities in South Africa and recommendations for further studies. The recommendations are based on observations throughout the study and the limitations faced during the study.

6.4.1. Recommendations to Organisations

Based on the findings of the study, the researcher recommends the following to the water utilities in South Africa to ensure sustainability:

- Water utilities are generally encouraged to adopt this study model and test it.
- As the first step to take, it is recommended that Operations Managers, Maintenance Managers and Programme Managers of utilities be trained on operations strategies, maintenance and capital expansion plans; and on the key role it plays in the sustainability of the utility. In so doing they should be tested on their understanding of the operations strategy, trade-offs and sustainability by use of professional personnel to identify the gaps.
- After gaps are established, a training matrix should be developed with clear training needs and milestones. Each manager should put these training needs on their personal development plans (PDP) and on their performance contract.
- After the gaps have been addressed there should be a robust plan to ensure that this work is sustained and embedded in the strategic imperatives of the water utilities.

6.4.2. Recommendations for Further Studies

It is recommended that this study be extended by taking a bigger sample of at least 200 to get enough data to be able to determine if trade-offs do not really have the mediating effect as hypothesised. In addition, the study should be extended to more water utilities and may also be extended to power utilities. Furthermore, comprehensive study could be undertaken in other industries such manufacturing industry to test the model and gain further insight from a different industry. This may provide positive benefits to struggling industries such as priority setting and resource allocation.

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8. APPENDIX 1: Questionnaire