OPERATION STRATEGY FOR WATER SUPPLY SERVICE DELIVERY IN LUSAKA'S UPRISING RESIDENTIAL AREAS. A CASE STUDY OF LUSAKA WATER AND SEWERAGE COMPANY.

BY

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This dissertation is submitted in partial fulfilment of the requirement for the degree of Master of Engineering in Engineering Management

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DECLARATION

I, Bweupe Lombanya, do hereby declare that this thesis represents my own work, and that all works of other persons used in this dissertation has been duly acknowledged, and that to the best of my knowledge has not previously been submitted at this or any other University for similar purpose.

Date: ……. Signature: ……

CERTIFICATE OF APPROVAL

This dissertation by **Bweupe Lombanya** is approved as a partial fulfillment of the requirements for the award of the degree of Master of Engineering in Engineering Management by the University of Zambia.

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DEDICATION

This research is dedicated to my Parents, my father Mr. Jerry Lefai Lombanya and my mother Mrs. Irene Lombanya. Their financial, spiritual and moral support throughout my education from an early age up to the completion of this research cannot be overstated.

ABSTRACT

Access to safe and affordable drinking water is a basic need for every human being. Therefore, the main aim of this study was to assess Lusaka Water and Sewerage Company's (LWSC) Operations Strategies in its endeavor to provide safe and affordable water services in Lusaka's uprising residential areas.

The research employed a non-intervention research design. The main primary data collection instruments used was structured questionnaires and structured interviews. 30 household questionnaires were administered to households in Libala, Chalala and Chelstone Obama residential areas respectively. Two water samples were collected randomly from each location and tested for quality. Borehole water from Chalala and Chelstone Obama was found to be contaminated with total and feacal coliform bacteria while the piped water in Libala was found to be compliant to World Health Organisation (WHO) standards. These finding were in line with previous water assessment studies that were done in similar locations less than two years ago. The average total cost for drilling and installing a borehole was K17, 351 with the reported minimum cost at K5000 and maximum at K75, 000. Majority of the respondents also reported that a decentralized water supply system was an innovative idea. The residents in Libala who already had piped water from LWSC were generally satisfied with the water services being rendered but had concerns over the high water tariffs, the late response to water problems and the elevated levels of chlorine in the water.

From the overall findings obtained, the main operational core competency identified was the quality of the product (water). As a result; for LWSC to easily connect the uprising residential areas of Lusaka to its main existing system, it was recommended that LWSC formulates a well-documented Operations Strategy that will focus on the cost of the service and time of service delivery. These can be achieved through a well thought out and implementable Capacity Strategy and Asset Management.

Key words: Operations Strategy, Capacity Strategy, Asset Management, Core-competency, Focus, Cost, Quality, Time

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

CSO	Central Statistics Office
JMP	Joint Monitoring Programme
LCC	Lusaka City Council
LWSC	Lusaka Water and Sewerage Company
LWSSD	Lusaka Water Supply, Sanitation and Drainage Project
MCC	Millennium Challenge Corporation
MCTI	Ministry of Commerce, Trade and Industry
MDGs	Millennium Development Goals
MLGH	Ministry of Local Government and Housing
MWDSEP	Ministry of Water Development, Sanitation and Environmental Protection
MWI	Ministry of Water and Irrigation
NRW	Non- Revenue Water
NWASCO	National Water and Sanitation Council
PHI	Presidential Housing Initiative
PUAs	Peri-Urban Areas
PWP	plant-within-a-plant
SDGs	Sustainable Development Goals
TNTC	Too Numerous To Count
UfW	Unaccounted for Water
UNDP	United Nations Development Programme

UNICEF	United Nations Children's Emergency Fund
WASH	Water Sanitation and Hygiene
WASREB	Water Services Regulatory Board
WHO	World Health Organisation
WSS	Water Supply Service

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter provides the background to the study in which the context of the study is given. The chapter also gives the statement of the problem and the main aim of the study together with the research objectives and questions that guided the study. In addition, the chapter gives the justification for the study and organisation of the dissertation.

1.2 Background to the study

Research and observations have shown that the majority of the earth's surface is covered with water. However, only 2.53% of the Earths water is fresh but less than 1% of this fresh water is readily accessible for direct human uses such as consumption, and demand for clean water continues to soar as the world population increases more and more. At the turn of the millennium, more than 40% of the Southern African countries had no access to water for basic needs. Consequently, avoidable water related diseases which prevail in the region result in high mortality rates. These diseases also lower productivity of large numbers of people and result in reduced human welfare (SADC, 2000).

Zambia is one of the countries blessed with abundant sources of water. However, the period before 1994 concerning provision and access to adequate clean and quality water, domestic water was characterized by; lack of adequate institutional framework, absence of coordination amongst organisational stakeholders, inadequate national policy on community participation, ineffective government policy on operation and maintenance, low coverage of health educational programmes on the benefits from better water and sanitation, absence of standardised pumping technology and water point designs and, limited financial resources to rehabilitate and upgrade existing decrepit water infrastructure (Banda, 2004).

In urban areas, the level of access to safe drinking water and adequate sanitation facilities were 70% and 43% respectively and only one-third of the rural population had access to safe drinking

water and sanitation facilities (WHO/UNICEF, 2015). This implies that slightly more than 50% of urban and close to 70% of rural population was prone to some water borne diseases due to poor sanitation. Urban areas also faced serious problems related to proliferation of illegal settlements especially on rich water aquifers and uncontrolled discharge of effluent into water sources. However, peri-urban areas considered to be legal settlements by government were treated as urban areas with regards to provision of water supply and sanitation facilities (Dagdeviren, 1989).

In 1994, the government committed itself to transforming the water sector to ensure quality provision of water supply and sanitation, at affordable costs and on a sustainable basis (WASH, 2015). The government formulated the National Water Policy which was adopted in 1994. The goals and objectives of this policy were as follows; the main goal was to promote a sustainable water resources development with a view to facilitate an equitable provision of adequate quantity and quality of water for all competing groups of users at acceptable costs and ensuring security of supply under varying conditions – establishing a well-defined institutional structure that will achieve the intended policy objectives. The objectives were; recognizing the important role of the water sector in the overall socio-economic development of the country, vesting ownership of water resources in the country under the state control, promoting water resources development through an integrated management approach, defining clear institutional responsibilities of all stakeholders in the water sector for effective management and co-ordination, developing an appropriate institutional and legal framework for effective management of the water resources, promoting a state of disaster preparedness to mitigate impacts of extreme occurrence of water (flood and drought), recognising water as an economic good and maintaining the fitness for use of water resources on a sustainable basis. The policy was oriented to provide adequate, safe and cost-effective water supply and sanitation facilities, to mention a few (Banda, 2004).

However, despite the various efforts that have been put by the government to improve the water supply and quality in Zambia, the increasing number of housing and private borehole drilling companies has a potentially harmful effect on the quality of ground water supplied in the households. To date, there is inadequate data on the quality of water supplied in the uprising housing project in Lusaka district. In that regard, this study looks at evaluating the institutional

framework put by Lusaka Water and Sewerage Company to manage the supply of water in the district. The study assessed the water service delivery of Lusaka Water and Sewerage Company in selected new residential areas and the core competencies that it needs to nurture to improve connection to these areas.

1.2.1 Sector Reforms

Prior to the sector reforms of 1994, the Zambian water sector was characterized by lack of guiding policy, very low-cost recovery, poor human resource both in terms of quality and quantity, decrepit infrastructure, and little or no investment for network expansion. Because of these problems, the water infrastructure throughout the country deteriorated to such an extent that over half of the water produced was lost before reaching the consumer. Lack of clearly defined roles and jurisdictional responsibilities led to both policy gaps and duplication of efforts in the sector system. There was no legislation to guide water and sanitation service provision and the management of water resources was not handled in a comprehensive manner. Overall, the entire sector was disorganized and service provision undesirable. The quality of water produced soon became a health hazard.

In 1994, the Government committed itself to transforming the water sector so as to ensure quality provision of water supply and sanitation, at affordable costs and on a sustainable basis. In 1997, the Government passed a National Water Policy in which seven sector principles were outlined as follows:

1. Separation of regulation and executive functions;
2. Devolution of supply responsibility to local authorities and private enterprise;
3. Promotion of appropriate technology for local conditions (in terms of ability to pay)
4. Increased Government, (GRZ) spending on Water Supply Services, WSS.
5. Creation of effective institutions through human resource development and capacity building;
6. Fully cost recovery through user changes (over the long term);
7. Separation of Water Resources Regulation from Water Supply and Sanitation, (WSS), Regulation.

In addition to the reforms, the Lusaka City Council (LCC) as a corporate body and agent of central government was delegated functions to provide services to residents of the city under the Local Government Act CAP 281. The 1991 Local Government Act and the Local Government Elections Act (with amendments) provides the institutional framework for the administration of Lusaka as a local authority and the holding of elections. LCC has seven elected Members of Parliament, one from each constituency; and thirty-three councilors, one from each ward. LCC consists of eight departments of which the Engineering Department is responsible for the provision of infrastructure (roads, drainage, and streetlights), fire brigade, and maintenance of open spaces, parks and gardens (LCC, 2017).

In 1988, the Government facilitated the de-linkage of the Department of Water and Sewerage from the LCC to form the Lusaka Water and Sewerage Company Limited (LWSC) under the Company's Act. LCC's Department of Water and Sewerage was thus transformed into a commercial utility company with a view to provide water supply and sanitation services within its area of jurisdiction, which was then the greater Lusaka City. However, since 2008, the area of jurisdiction and operating license of LWSC has been extended to cover the whole of Lusaka province and now includes the councils of Chongwe, Kafue and Luangwa as the new shareholders of the company (Ndongwe, 2013).

1.2.2 Lusaka Water and Sewerage Company Profile

The noble function of supplying water and sanitation services to Lusaka province was previously managed by the Lusaka Municipal Council under the Engineering Department until 1988 when Lusaka Water and Sewerage Company (LWSC) took over the reins.

Lusaka Water and Sewerage Company is therefore a commercial water utility providing water and sanitation services to the Lusaka Province of Zambia. This Company was established in 1988 under the Company Act and commenced operations in 1990. Staff and some assets belonging to the Water and Sewerage Department of Lusaka City Council (LCC) were transferred to LWSC. Assets were fully transferred in 2003 through Statutory Instrument 26 of 2003, and in 2008, LWSC became a provincial utility.

Figure 1.1 shows the current areas of operation for Lusaka Water and Sewerage Company which are; Lusaka, Rufunsa, Luangwa, Chongwe, Chilanga, Chirundu, Kafue, and Sibuyunji (LWSC, 2017).

Figure 1. 1: LWSC areas of operations (Source: Google Map)

1.2.2.1 Organization Structure and Governance

LWSC is organized and governed as illustrated in Figure 1.2. The major shareholder for LWSC is the Lusaka City Council. The Shareholders have the responsibility of appointing the Board of Directors. Being guided by the Board Charter, the board appoints the Managing Director who oversees operations of the company. LWSC has five departments each headed by a respective Director (LWSC, 2017). The departments are;

1. Engineering
2. Commercial Services
3. Human Resources and Administration
4. Finance
5. Infrastructure, Planning and Design

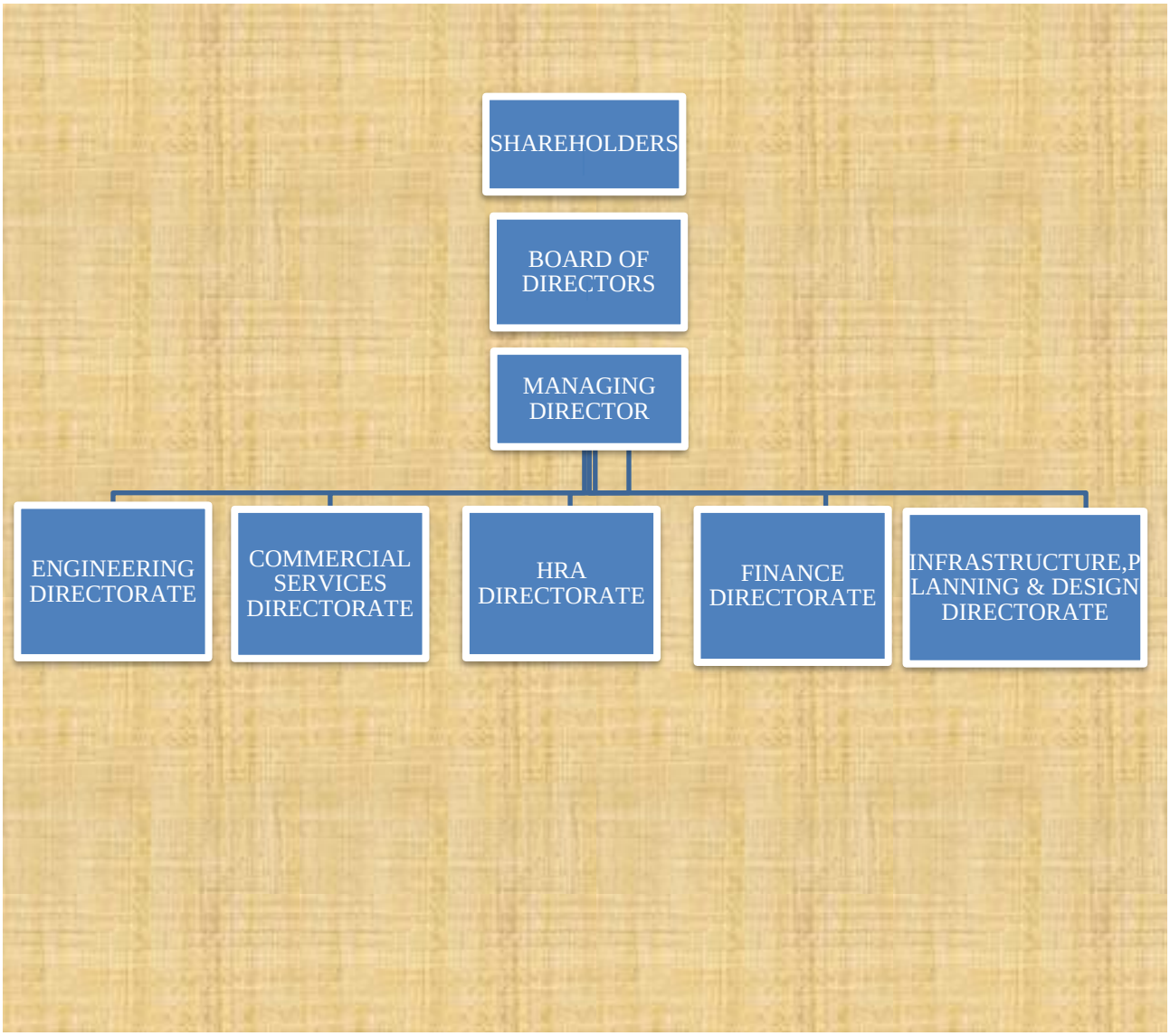

Figure 1. 2: Organization Structure for LWSC

1.2.2.2 Mission, Vision, Corporate Focus and Core Values

(a) Mission

To provide quality water and sanitation services at a commercially and environmentally sustainable levels to the delight of our customers and other stakeholders

(b) Vision

A world class company working together to change lives and bring pride to communities through provision of water and sanitation services.

(c) Corporate Focus

LWSC corporate focus revolves around its endeavor to improve profitability, reduce non-revenue water, provide reliable water and sanitation services to Lusaka Province, improve customer service, improve productivity of human capital, implementation of Total Quality Management System(TQMS) and the enhancement of its corporate social responsibility.

(d) Core Values

LWSC strives to embrace the core values shown in Figure 1.3 (LWSC, 2017).

Figure 1. 3: LWSC core values.

1.2.2.3 Policy and Legislative Framework

Figure 1.4 shows the policy and legislative framework that supports LWSC. The main players are Ministry of Local Government and Housing (MLGH) and the National Water and Sanitation Council (NWASCO). The Ministry of Local Government and Housing is in charge of sector policies while NWASCO is the economic regulator of Water and Sanitation services. NWASCO oversees tariff adjustments, minimum service levels, financial projection and investment planning and corporate governance. NWASCO however reports to the Ministry of Energy and Water Development (Ndongwe, 2013).

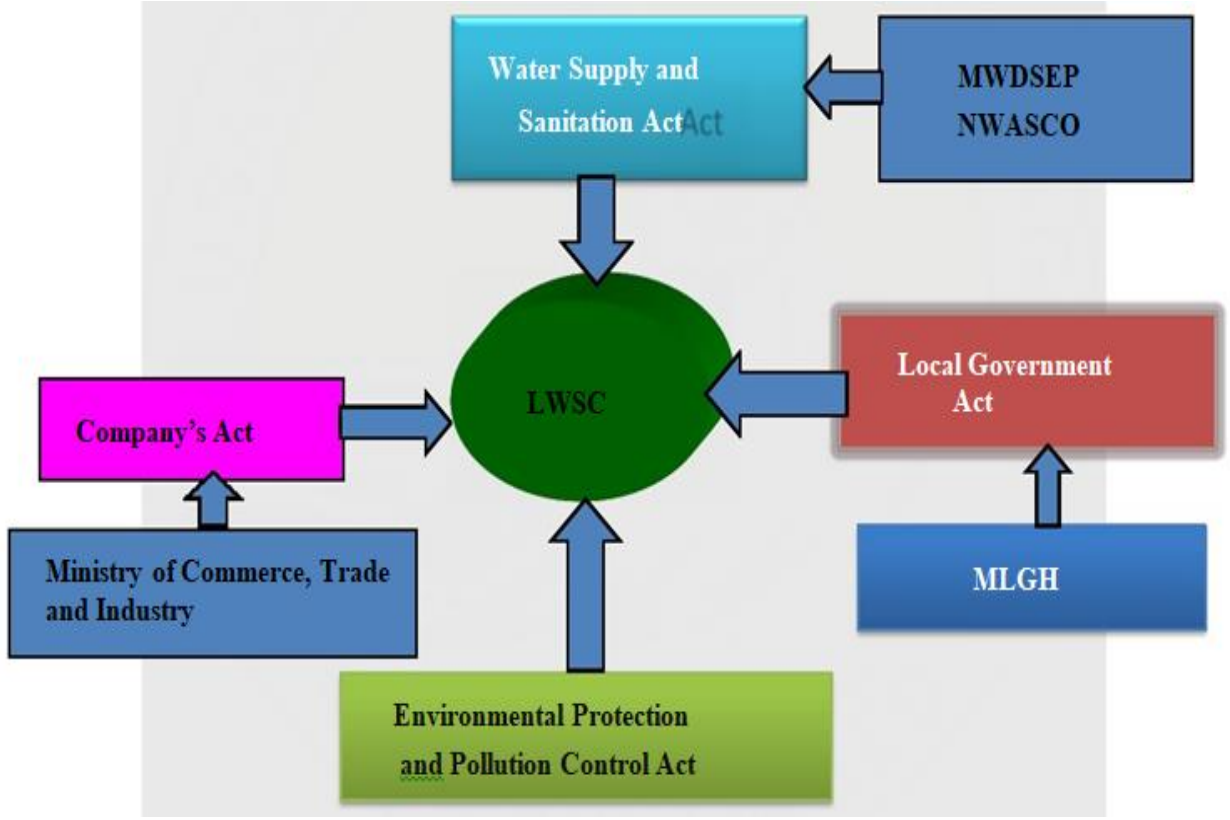

Figure 1. 4: Legislative Framework governing Lusaka Water and Sewerage Company

1.2.2.4 Operations Overview

By 2014 (LWSC) was supplying a population of about 2.3 million people and about 70% of the population resided in Peri-Urban Areas. These are high density, largely unplanned settlements. As a result, LWSC has been having serious challenges in supplying water and sanitation

services. This has made LWSC to be licensing water trusts to provide water services to some parts of Peri-Urban (Ndongwe, 2013).

LWSC had 1308km of network of network pipe materials. Average daily water production was 258,000m^3 and was supplied from two main water sources, that is the Kafue river and boreholes which account for 43% and 57% of water supplied respectively (ibid). Both types of sources are considered to be good, but in some areas the groundwater is polluted by sewage and other contaminants (for example, solid waste dumps or industrial spills) percolating down to the aquifer. Treatment and disinfection of borehole water is not always adequate, and some boreholes are regarded as unsafe sources. However, with proper control of sources of pollution in the recharge areas combined with chlorination of water from LWSC boreholes, groundwater is an economic and reliable source of water (Millenium Challenge Corporation, 2011).

1.3 Statement of the problem

In most developing countries, there is growing displeasure with the public service delivery. Scarcities in the coverage, access and quality of basic services and infrastructures such as water supply and roads are common (Paul, 1992; OECD, 2008). UNDP (2006), for example, indicated that there are around 1.2 billion people in the world who lack access to sufficient quantities of safe water. Like most countries in the developing world, African countries have major difficulty in providing effective and equitable public services (ECA, 2005b). Zambia is currently a leading source of clean water in Sub-Saharan Africa harboring approximately 35% of the fresh water sources. Despite this being the case, the increasing population and urbanization that is taking place has put pressure in the water resource and the quality of water available for consumption. The current statistics prove that Lusaka Province is the fastest growing province with an annual rate of population growth of 4.6% (CSO, 2014) which entails that the province has increasing demand on housing, water and sanitation. However, evidently the rapid development and expansion of residential areas in the outskirts of the city has outplaced the installation of water supply systems by the local utility company. Due to this inability by LWSC to meet the rising demand, most residents have now resorted to drilling boreholes for their daily water use.

In spite of the need to supply the much needed water commodity in the province very few chemical data are available for groundwater in Zambia on which to base an assessment of the

quality of available resources and reconnaissance testing programs are urgently needed to establish the drinking-water quality. The Lusaka Water and Sewerage Company has on several times registered its concerns over the construction boom which is a threat to the water table and the quality of water and sanitation in the housing projects (Times of Zambia, 2016). The cost incurred by the residents in installing and running these boreholes is quite high, and only very few published tests have been done in these areas to ascertain the safety of this water for human consumption which poses a health risk. The importance of safe and up to standard drinking water cannot be over emphasized in any sector of society. Provision of satisfactory service to the public is key to the success of Lusaka Water and Sewage Company. This study will therefore assess Lusaka Water and Sewerage Company's Operations Strategies in its endeavor to provide safe and affordable water services in Lusaka's new residential areas.

1.4 Main Objective

The study aims at assessing Lusaka Water and Sewerage Company's Operations Strategies in its endeavor to provide safe and affordable water services in Lusaka's new residential areas.

1.5 Specific Objectives

To meet the main objective of the study, the specific objectives below will guide the research;

1. To assess the institutional framework including operations strategies put in place by Lusaka Water and Sewerage Company to monitor the quality of Water and Sanitation services in new residential areas.
2. To examine the challenges faced by LWSC in connecting new housing units to the existing system.
3. To investigate physical, chemical and microbiological quality of water supplied in selected residential areas of Lusaka District.
4. To analyse the feasibility and acceptability of LWSC putting up decentralised water supply system in the new residential areas.

1.6 Research Questions

1. What institutional framework has LWSC put in place to monitor the quality of water supplied in households and what are its Operational Core Competencies?
2. What challenges are faced by LWSC in connecting new housing units to the existing system?
3. What is the physical, chemical and microbiological quality of groundwater supplied in the selected residential areas?
4. What is the feasibility of LWSC putting up decentralized water supply system in the new residential areas?

1.7 Justification of the Study

The water sector was chosen on grounds that equitable access to adequate quantities of good-quality water is central to growth and sustainable development. Water is a vital input to livelihoods not only domestically but also in most economic sectors. Access to affordable safe water is also central to alleviating poverty and achieving the Sustainable Development Goals (SDGs). Thus, the importance of this research cannot be doubted due to importance of water for human survival.

The researcher also recognizes that there is insufficient empirical evidence on the effectiveness of the national water policy in regulating the quality of underground water supplied in the residential areas of Lusaka and other areas in Zambia. Therefore, this study will contribute to the body of knowledge on the quality of ground water in residential areas. The research will also aim at assessing the extent of borehole usage in the selected areas with the hope of findings cost effective solutions to the water problems faced by the residents. The findings of this research project could be used by various stakeholders of the government in formulating and forecasting certain policies that are relevant in relation to the problem at hand.

1.8 Organisation of dissertation

The dissertation is organized in six chapters. Chapter one is composed of the: background to the study, statement of the problem, main objective, specific objectives, research questions, justification of the study and organization of the study. Chapter two presents reviewed literature

relevant to the study while Chapter three outlines the methodology. Research findings are presented in Chapter four. Chapter five discusses the findings of the research and Chapter six gives the conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the study literature review that helps put into context the problem under investigation. The literature review is divided into three components. The first part will have the study conceptual framework that helps understand the consumer side of water demand and the other part will have the marketer's perceptions of the needs of the consumers and operation strategies. The last part of the literature review will focus on studies that have been done on the effects of poor water supply in residential areas.

2.2 Conceptual Framework

A conceptual framework of supply and demand can be used to distinguish between the behavior and incentive systems of organisations and consumers (Colander, 2013). The consumer's choices of a particular commodity are largely based on the price of the commodity and its availability on the market. With regard to water supply, consumers' choices are also based on their past experiences with a water service provider. Usually, when consumers have had an unpleasant experience with a service provider, they tend to focus on other alternatives. In addition, most consumers especially in new residential areas have other urgent personal needs that they are willing to finance regardless of the cost. This can come because of their personal needs to have consistent water supply, long term benefit of installing a private borehole and the bureaucracy surrounding installing water supply systems in households. With that in mind, most consumers, not only in uprising residential areas end up settling for private borehole installations which could create a problem for LWSC in future.

On the other hand, the marketer who in the case of Lusaka District is Lusaka Water and Sewerage Company, whose primary mandate is to provide water and sanitation services in housing units. The marketer, just like the consumer should have the institutional capabilities to fully provide water services especially to the uprising new residential areas. Necessarily infrastructure has to be put in place in order to provide water and sewerage services in the most sustainable and cost effective manner. In addition, the utility company also has to go through the

process understanding the consumer's perceptions and needs of good service and later translate it into actual services. This is anchored on the fact that; the demand is quite high not only in the new residential areas but other areas with high populations that have no access to water and have no financial capabilities to install private boreholes. In the wake of this, this research will look at the feasibility of LWSC putting decentralized systems that will not only supply water but also improve the quality of water supplied. Figure 2.1 shows the conceptual framework that can be used by the water utility company in understanding consumer choices to improve water service delivery.

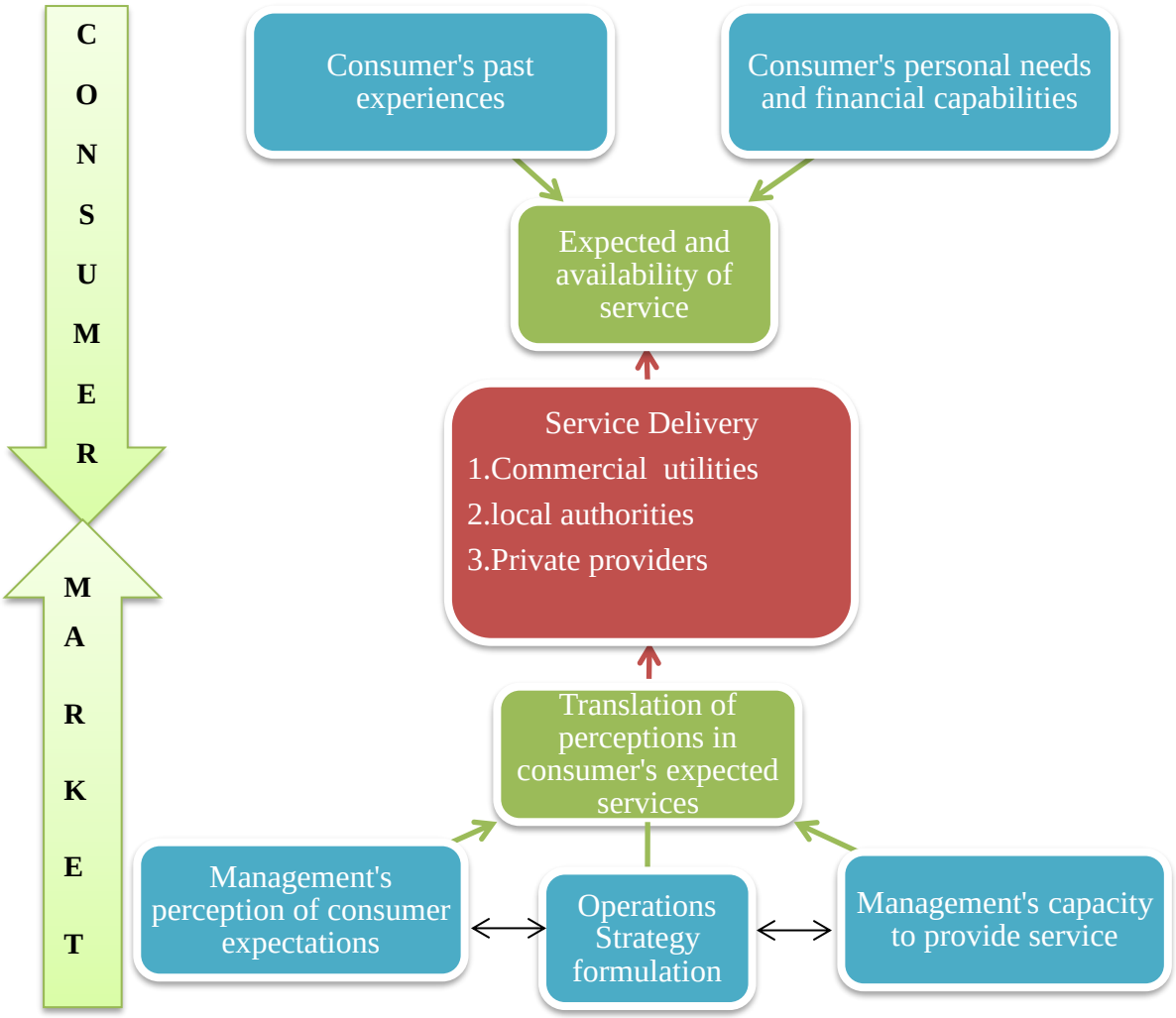

Figure 2. 1: Conceptual Framework of water provision and Consumer choices

2.3 Operations Strategy

To understand the concept of Operations Strategy, it is imperative to first review the meaning of Strategy and Operations. Strategy means a specific plan of action to reach a particular objective. Organisations develop strategies for the purpose of value maximization which is determined by the Net Present Value (NPV) of an Organisation. On the other hand, according to the Merriam-Webster dictionary (2007), Operations is the performance of practical work or of something involving the practical application of principles or processes.

Operations Strategy is therefore concerned with setting of broad policies and plans for using the resources of the firm to best support its long term competitive strategy (Chase, Jacobs, & Acquilano, 2006). Mieghem & Jan (2008) further on defines it as a plan for developing resources and configuring processes such that resulting competencies maximize net present value. Operations Strategy answers mainly two questions;

1. What should operations be good at? Which competencies should it nature?
2. Which operational system of resources and processes best provide these competencies (ibid).

The Operation Strategy of an organisation is always related to its Competitive Strategy. However, it has a distinct role just like the Marketing Strategy and the Financial Strategy. Competitive Strategy is more about selecting industries and choosing the product attributes on which to compete while operations strategy focuses on enabling the execution of the business strategy on how best to deliver value position. Figure 2.2 shows how Operations Strategy relates to the overall Business Strategy of an organisation.

Figure 2. 2: How operations strategy relates to the Business Strategy © Wiley 2010

2.4 How Operations Strategy differs from Operations Management

Businesses often confuse operations strategy to operations management, and this can be one of their biggest mistakes. Operations management is mainly concerned with short to medium time-scales while operations strategy deals with long term issues. Operations management involves the managing of resources within and between smaller operations mostly work units or departments, whereas operations strategy is concerned with a higher level of analysis where decisions that affects a wider set of organisation resources and the supply network are made. Operations management looks at how products and services are produced, treating individual sets of resources separately as components of operations while operations strategy involves a greater level of aggression that brings together and consolidates such details into broader issues. Lastly, operations management is concerned largely with what is immediately recognizable and tangible while operations strategy deals with more abstract, less directly observable issues (Slack & Lewis, 2015).

2.5 Three Views of Operations

2.5.1 The Resource View

For an organisation to be well coordinated and perform its activities with great effectiveness, it needs a wide variety of real assets and resources. Real assets and resources usually refer to all

means needed to perform activities excluding financial assets. The resource view deals with Capacity Sizing (how much capacity should we invest in?), Timing (when to increase or reduce resources), Type (what kinds of resources are best?) and Location (where should resources be located) (Mieghem & Jan, 2008).

2.5.2 The Process View

The main purpose of the process view is to highlight how resources perform activities and add value. Processes are usually structured reoccurring activities that transform inputs into outputs. A process has a network of activities with specific precedence relationship among the activities. Process strategy will answer to questions such as which activities do we perform internally, which are outsourced and how do we manage suppliers? Which technologies do we need? How do we match demand to available supply? And how do we much improve and innovate? (ibid)

2.5.3 The Competency View

The presence of resources and processes helps the formulation of an operational system which determines what an operation can and cannot do. This further determines the competencies of an organisation. Firms' competitive priorities and their areas of diction set the limit on the content of operations strategy. Both concepts are strongly interrelated as operations decisions and competitive priorities must be congruent. The fit between these variables and the necessary investments in operations structure and infrastructure may justify the role of operations area as a source of sustainable competitive advantage and continuous improvement (Roth, 1989; Anderson et al., 1989). Key to success in operations strategy lies in identifying what the priority choices are in understanding the consequences of each choice and in navigating the ensuring tradeoffs (Lee and Ritzman, 2005).

2.5.3.1 Competitive priorities of the operation function

Before determining the competitive priorities of an organization, it is imperative that operations managers work hand in hand with marketing. This will help them understand the competitive situation of the organization or company. The competitive situation is usually driven by the different customer preferences of the product. The major competitive dimensions that form the competitive position of an organization are Cost, Quality, Time and Flexibility.

(a) Cost

When an organization competes based on cost, it means that it tries to offer a product at a lower price compared to its competitors. Within every industry, there is always a market segment that buys solely on the basis of low cost. This segment is usually large and hence companies are attracted by the potential for large profits or revenue which can be realized by producing large unit volumes. Consequently, the competition is fierce in this segment and the failure rate is also high. The role of operations strategy in this segment will be to develop a plan for the use of resources to support this dimension of competition. Usually, an organization that adopts the priority of cost will invest in studying their operations system to ensure that all waste is eliminated (Chase, eta l., 2006).

(b) Quality

There are two types of features of products or services that define quality; design quality and process quality. Design quality usually refers to characteristics of a product or service that it contains. Process quality is critical because it directly relates to the reliability of the product or service. It deals with designing a process that produces error free products or services.

Quality is a term that is subjective which means that it depends on who is defining it. For instance, for one person, quality might mean that the product lasts longer while for another person it might mean high performance. A company that competes on this dimension needs to implement quality in every area of the organization. When organizations pick on quality as their competitive priority, it simply means that they are focusing on dimensions of quality that are considered most important by their customers (Magutu, et al., 2010).

(c) Flexibility

As a company's environment changes rapidly, including customer needs and expectations, the ability to readily accommodate these changes can be a winning strategy – this is flexibility. There are two dimensions of flexibility. One is the ability to offer a wide variety of goods or services and customize them to the unique needs of clients. This is called product flexibility. A flexible system can quickly add new products that may be important to customers or easily drop a product that is not doing well. Another aspect of flexibility is the ability to rapidly increase or

decrease the amount produced in order to accommodate changes in the demand. This is called volume flexibility (Vokurka and O'Leary-Kelly, 2000).

(d) Time

The importance of time or speed as a competitive priority cannot be overemphasized in today's business world. Most successful companies nowadays always endeavor to deliver quality products in a short time possible. When time is a competitive priority, it means an organization's operation function needs to analyze the system and eliminate all issues that can cause time to be lost. This tends to make organizations invest in various technologies and state of art equipment that would eliminate unnecessary steps in the production and delivery processes. (Rondeau, et al, 2000)

2.5.3.2 The need for trade offs

The notion of operations focus and tradeoffs is central to the concept of operations strategy. The Merriam Webster dictionary (2007) describes a tradeoff as "a balancing of factors all of which are not attainable at the same time; a giving up of one thing in return for another." When more resources are dedicated to one priority, fewer resources are left for the others. Therefore, the operation function places more emphasis on those priorities which support the business strategy. For example, if a company wants to focus on speed of delivery, it cannot be flexible enough to offer a wide range of products. Similarly, consider a company that is using components of the highest quality in its products. Due to the high quality, the final product will most likely be offered at a high price. Therefore, in such a case, the company will make a tradeoff between quality and cost (Chase, eta l, 2006).

One way that large facilities with multiple products can address the issue of trade-offs is using the concept of plant-within-a-plant (PWP), introduced by well-known Harvard professor Wickham Skinner. The PWP concept suggested that different areas of a facility be dedicated to different products with different competitive priorities. These areas should be physically separated from one another and should even have their own separate workforce. As the term suggests, there are multiple plants within one plant, allowing a company to produce assorted products that compete on different priorities. For example, department stores use PWP to isolate

departments, such as the Sears auto service department versus its optometry center (Ward & Duray, 2000).

2.6 Concept of the Efficient Frontier

The Efficient Frontier is a snapshot that traces the industry's lowest cost to produce specific competency bundles of variety, quality and timeliness.

Figure 2.3(a) shows the relative performance of several companies in the same industry in terms of their cost efficiency and the variety of products or services that they offer to their customers. Presumably all the operations would ideally like to be able to offer very high variety while still having very high levels of cost efficiency. However, the increased complexity that a high variety of product or service offerings brings will generally reduce the operation's ability to operate efficiently. Conversely, one way of improving cost efficiency is to severely limit the variety on offer to customers. The spread of results in Figure 2.3(a) is typical of an exercise such as this. Operations A, B, C and D all have chosen a different balance between variety and cost efficiency. But none is dominated by any other operation in the sense that another operation necessarily has 'superior' performance. Operation X, however, has an inferior performance because operation A is able to offer higher variety at the same level of cost efficiency, and operation C offers the same variety but with better cost efficiency. The convex line on which operations A, B, C and D lie is known as the 'efficient frontier'. They may choose to position themselves differently (presumably because of different market strategies) but they cannot be criticized for being ineffective. Of course, any of these operations that lie on the efficient frontier may come to believe that the balance they have chosen between variety and cost efficiency is inappropriate. In these circumstances they may choose to reposition themselves at some other point along the efficient frontier. By contrast, operation X has also chosen to balance variety and cost efficiency in a particular way but is not doing so effectively. Operation B has the same ratio between the two performance objectives but is achieving them more effectively. Operation X will generally have a strategy that emphasizes increasing its effectiveness before considering any repositioning.

However, a strategy that emphasizes increasing effectiveness is not confined to those operations that are dominated, such as operation X. Those with a position on the efficient frontier will

generally also want to improve their operations effectiveness by overcoming the trade-off that is implicit in the efficient frontier curve (Slack & Lewis, 2015).

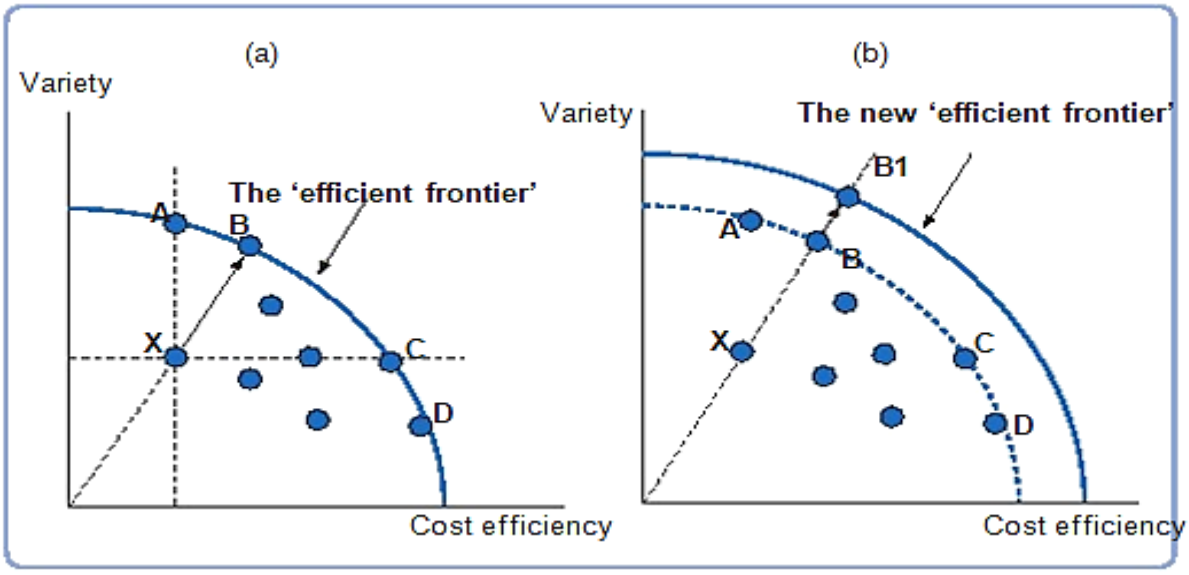

Figure 2. 3: The efficient frontier (Slack & Lewis, 2015)

2.7 Operational Efficiency

Operational efficiency is the capability of an enterprise to deliver products or services to its customers in the most cost-effective manner possible while still ensuring the high quality of its products, service and support (Mieghem & Jan, 2008).

2.8 Operational Effectiveness

Operational effectiveness involves any number of practices that enable an organization to (i) better utilize its resources, (ii) better implement its processes, and (iii) achieve its mission and goals. In other words, operational effectiveness is about continuously improving functional performance. In order to accomplish this, managers lead and control the functional activities within the organization, measure and improve the processes for which they are responsible, and then close the loop by leveraging those improvements for enhanced functional effectiveness. It is then the role of strategy to mold these functions into a coherent organizational whole that will succeed in the marketplace. (ibid)

2.9 The concept of Focus in Operations

A focused operation is an operation whose required competencies are restricted to a narrow set in the competency space of cost, variety, speed, and quality. Focus is a joint property of the operational system and of the way we choose to utilize that system (ibid).

Most of the early work on what was then called the 'focused factory' concept was carried out by Wickham Skinner of Harvard Business School. Based on his ideas of how tradeoffs dominated operations decision making, he argued that one way of achieving an effective operations strategy is through the concept of factory focus. This meant that first a business should establish a consistent set of policies for the various elements of its operations, which will support not only each other but also marketing requirements. Second, because of the inherent tradeoffs, one operation cannot provide peak performance in all performance objectives at the same time. In his article 'The Focused Factory', Skinner based these arguments on his observations of a variety of US industries in the early 1970s. He found that most factories were trying to tackle too many tasks and therefore trying to achieve too many objectives. Because of this they were failing to perform well in any single objective. He concluded that a factory that was focused on a narrow range of products and aimed at satisfying a particular section of the market, would outperform a plant that was attempting to satisfy a broader set of objectives. The equipment, systems and procedures that are necessary to achieve a more limited range of tasks for a smaller set of customers could also result in lower (especially overhead) costs. Focus, according to Skinner, can be expressed as dedicating each operation to a limited, concise, manageable set of products, technologies, volumes and markets, then structuring policies and support services so they focus on one *explicit* task, rather than on a variety of inconsistent, conflicting, *implicit* tasks. Operational focus simply increases operational efficiency (Skinner, 1974).

Firms can use a various criterion to focus their operations. Appendix 5 shows the criteria that can be used.

2.10 Capacity Strategy and the Concept

One of the core decisions in operations is capacity. Therefore, capacity strategy decisions are some of the decision that affects large part of organizations. Capacity Strategy is the long-term

plan for developing resources and involves decisions on sizing, timing, type, and location of real assets or resources. Too much capacity underutilizes resources and drives cost up. Too little capacity limits the operation's ability to serve customers and therefore earn revenues.

All organizations have bundles of resources that enable them to perform their activities. However, not all resources are available in abundance. Resource limitations are therefore captured by the capacity, which typically represents the maximum sustainable output rate of that resource (Slack & Lewis, 2015)

The capacity strategy of an operation defines its overall scale, the number and size of different sites between which its capacity is distributed, the specific activities allocated to each site and the location of each site. There are three levels of capacity decision as illustrated in Table 2.1. The overall level of capacity is influenced by several factors particular to each operation and its competitive position. Figure 2.4 illustrates these factors.

Table 2. 1: Three levels of capacity decision

Level	Time-scale	Decisions concern provision of.	Span of decisions	Starting point of decision	Key questions
Strategic capacity decisions	Years–Months	Buildings and facilities Process technology	All parts of the business	Probable markets to be served in the future Current capacity configuration	How much capacity do we need in total? How should the capacity be distributed? Where should the capacity be located?
Medium-term capacity decisions	Months–Weeks	Aggregate number of people Degree of subcontracted resources	Business – site	Market forecasts Physical capacity constraints	To what extent do we keep capacity level or fluctuate Capacity levels? Should we change staffing levels as demand changes? Should we subcontract or off-load demand?
Short-term capacity decisions	Weeks–hours–minutes	Individual staff within the operation Loading of individual facilities	Site Department	Current demand Current available capacity	Which resources are to be allocated to what tasks? When should activities be loaded on individual resources?

Source: (Slack & Lewis, 2015)

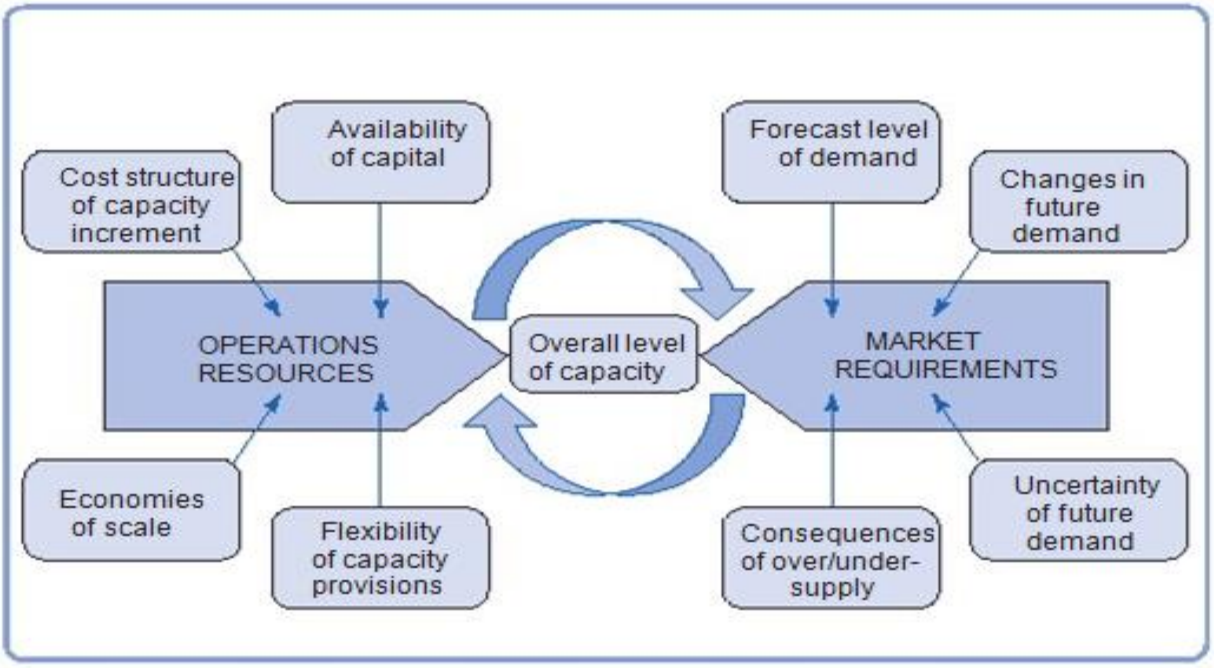

Figure 2. 4: Some factors influencing the overall level of capacity. (Slack & Lewis, 2015)

2.11 Framework for formulating operations strategy

A framework for formulating operations strategy is inspired by the principle of strategic fit. This framework is thought to answer three types of questions:

1. How does the organization seek to compete and provide value to its customers? For each targeted customer segment, how is the customer value proposition prioritized around cost, time, quality and Flexibility?
2. What must operations do particularly well? For each targeted customer segment, how are the operations' competencies prioritized around cost, flow time, quality, and flexibility?
3. Which resources and processes best provide that competency prioritization? For each targeted customer segment, how are the asset portfolio (sizing, timing and location of each resource type) and the activity network (supply, technology, demand and innovation management) configured?

The Figure 2.5 illustrates a framework for formulating an Operation Strategy (Mieghem & Jan, 2008).

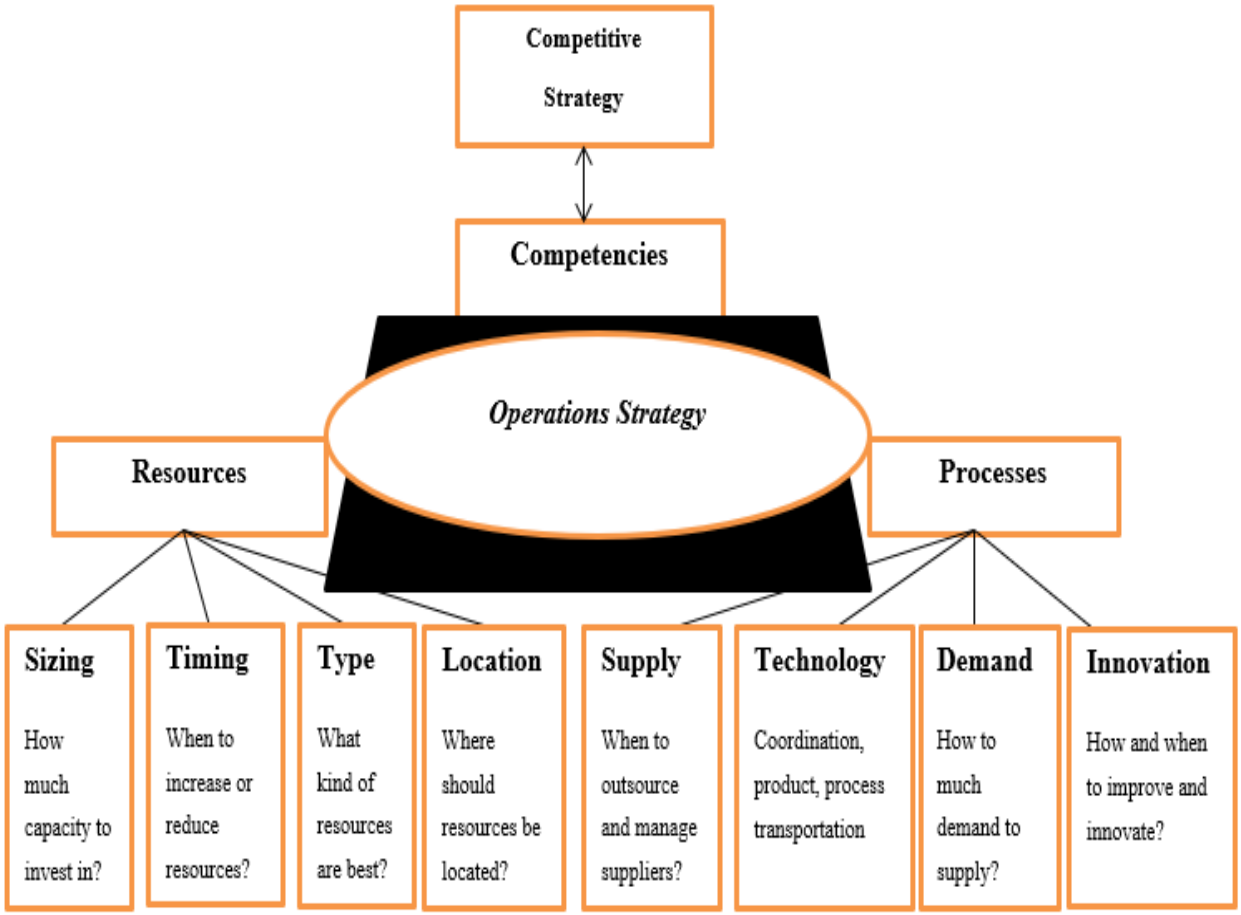

Figure 2. 5: Framework for formulating operations strategy (Mieghem & Jan, 2008)

2.12 Other Operation Strategy Terms and Principles

(a) Operational Risk Management

Risk management in this case is the broad activity of planning and decision making designed to deal with the occurrence of hazards or risks. Risk management in operations strategy can be thought of as a four-step process that starts with identification of hazards, risk assessment, tactical risk decisions and finally the implementation of strategic risk mitigation or hedging (ibid).

(b) Operational Hedging

Operational hedging is a process of strategic risk mitigation. It involves the structuring of resources and processes to reduce future risk exposures. This makes it integral part of operations

strategy. The four hedging strategies are reserves & redundancy, diversification & pooling, Risk sharing & Transfer and the reducing or eliminating the root cause of risk (Mieghem & Jan, 2007).

(c) Strategic Risk Mitigation

Strategic Risk Mitigation involves configuring the operational system for speed and flexibility so as to mitigate future risk exposures. It main goal is to design a resilient organization (Sheffi, 2005).

(d) Improvement and its importance in Operations Strategy

The only thing that is constant is change. Customers' expectations and preferences change, as do competitors' competencies and value propositions. How to stay ahead and align operational competencies to changing customer preferences is always a fundamental concern in operations strategy. Two modes of improvement are used in operations strategy, which is Radical improvement and Continuous improvement.

(e) Radical Improvement: Reengineering

Radical Improvement typically involves a drastic restructuring of operational system and of how work gets done. It often involves adoption of different resources and processes. Reengineering advocates for the fundamental rethinking and radical redesign of business processes in order to achieve dramatic improvements in critical temporary measures of performance such as cost, quality, service and speed (Hammer and Champy, 1993).

(f) Continuous Improvement

Continuous Improvement is the aggregate result of numerous small improvements in the way work gets that people are constantly making throughout the organization. Collins (2001) describes traits of "good to great" companies (such as Walgreens, Kroger, and Gillette) that consistently follow a disciplined process of continuous improvement in core competencies. Imbedded in continuous improvement are principles of lean and waste reduction and also the Six Sigma and variability reduction.

(g) Innovation

Every organization needs to develop innovative products, services and business models. As crucial (and often overlooked), is the need to develop innovative ways to deliver such products and services. To meet these challenges, the integration of innovation management with operations strategy is fundamental (Cranfield University, 2017). Innovation is about creating something new. It is traditionally understood as a radical change. However, some companies innovate through incremental change that may or not accumulate to radical change (Mieghem & Jan, 2007). Innovation projects with significant unforeseeable uncertainty can use a tailored management approach that depends on their relative cost and value of obtaining information early (Loch, eta l, 2006).

2.13 Review of empirical evidence

The U.N. Millennium Development Goals (MDGs) for water and sanitation are to halve the proportion of people without access to improved drinking water and sanitation facilities between 1990 and 2015 (WHO and UNICEF, 2013). Despite meeting the water goal and progressing towards the sanitation goal, at the end of 2011 there remained 768 million people without access to an improved water source and another 2.5 billion without access to improved sanitation facilities (ibid). Lack of access to improved water and sanitation facilities can result in diarrheal illness, which causes 760,000 deaths among children under 5 each year (WHO, 2013). This lack of access can also lead to respiratory illness (Luby and Hadler, 2008). Worldwide, acute lower respiratory infections caused over 900,000 deaths among children under 5 in 2013 (WHO, 2014). By 2030 the water and sanitation SDGs aim to achieve universal, equitable access to drinking water and sanitation (United Nations, 2014). In order to achieve this ambitious goal, significant expansion of water and sanitation infrastructure will be required. Common strategies to provide better access to water and sanitation facilities have included introducing community wells, point of use water disinfection, and latrines to rural communities (Fewtrell et al., 2005; Wolf et al., 2014).

More than 50% of the world's population lived in cities in 2011 and additional urbanization is expected; in Africa, the urban population is projected to triple by 2050 (United Nations, 2012). Many cities are not equipped with the necessary water and sanitation infrastructure to support

such substantial urban population growth. In 2011, an estimated 132 million and 728 million urban dwellers did not have access to improved water and sanitation, respectively (WHO and UNICEF, 2013). Zambia, where approximately 40% of the population lives in urban areas, is not on track to reach the MDGs (WHO and UNICEF, 2013). From 1990 – 2011 the proportion of the urban population with access to improved water sources decreased from 89% to 86%, and the proportion with access to improved sanitation also decreased, from 61% to 56% (WHO and UNICEF, 2013).

Limited access to adequate water and sanitation is one of the key developmental challenges faced by Zambia. Zambia has a high poverty rate, at 74% in 2010 (using a Purchasing Power Parity at US$1.25 per day), compared to 49% in the World Bank's low income countries aggregate grouping (World Bank, 2015).

The lack of adequate water and sanitation infrastructure is apparent in Lusaka, where the current infrastructure - built in the 1960s and 1970s for a population of 300,000 - is not sufficient to meet the needs of the current population of 1.8 million (Central Statistics Office, 2011). The situation is especially acute in low-income, peri-urban areas (PUA) in Lusaka, which constitute approximately 70% of the Lusaka population. In 2010, only 24% of peri-urban households had piped water to the home or plot, and nearly 60% collected their water from community sources such as kiosks (ibid). Lusaka Water and Sewerage Company (LWSC) estimates that water is available an average of 17 hours per day in the network, however, some peri-urban areas have access to water for an average of only 4 hours per day (CDC, unpublished data).

Access to sanitation infrastructure in PUAs is similarly low, where nearly 88% of households use pit latrines (Central Statistics Office, 2010). However, a majority of these pit latrines do not meet the definition of "improved" (for example, pit latrines without a slab or shared pit latrines) (Central Statistics Office, 2012) and many are not properly constructed (Millennium Challenge Corporation, 2012). Coupled with the karst geology in much of Lusaka, Gauff Ingenieure (2013b) - which is highly permeable and characterized by caves and cracks - these latrines can contaminate the shallow wells that some peri-urban residents use as a water source (MCC, 2012), and can lead to diarrhea illness and outbreaks.

The drainage infrastructure in Lusaka is also challenged and has degraded from a lack of maintenance (MCC, 2012). In addition, informal residential areas have been built in areas that are close to drains, and these areas are particularly prone to flooding (Ingenieure, 2013b). Topographically, Lusaka is fairly flat, and consequently, parts of the city are inundated each rainy season (November to April), leading to additional risk of waterborne illness (ibid). Furthermore, because Lusaka has a high water table (Ingenieure, 2013c), flooding can be severe and longer in duration in areas with karst geology when the water table reaches the ground surface (Ingenieure, 2013b).

Given the current state of WASH infrastructure in Lusaka, its expansion and revitalization will become increasingly more important to health and well-being as urbanization trends continue. The infrastructure interventions planned as part of the compact aim to, among other things, decrease waterborne disease and promote economic growth by building new and rehabilitating existing community kiosk connections, expanding residential water supply and sanitation networks to underserved areas, and rehabilitating the drainage system.

A review of the literature offers convincing evidence for the benefits of better WASH infrastructure. The importance of water supply has been shown in meta-analyses that found water supply interventions - such as installing standpipes or household connections - reduce diarrheal illness by 25-37% (Fewtrell et al., 2005; Wolf et al., 2014). A meta-regression conducted by Wolf et al. (2014) to identify the health effects of different types of water supply interventions found a relative risk for diarrheal disease of 0.86 (95% CI: 0.72, 1.03) from interventions that provided piped water connections (with non-continuous flow) to households that previously relied on improved community sources (for example, stand pipes), and a relative risk of 0.21 (95% CI: 0.08, 0.56) in interventions that provided continuous, high quality piped water connections to households that previously relied on improved community sources. While the illness reduction from a continuous connection is based on limited evidence from a single study, the meta-regression identifies the health benefits that can be achieved from household connections that provide continuous water supply, which are envisioned in the intervention in Lusaka.

The health benefits of closer and more reliable access to water sources has been shown in several other studies. For example, one multi-country study in sub-Saharan Africa found that even a 5-

minute decrease in one-way travel time was associated with decreased diarrheal disease incidence and improved weight-for-age measures (Pickering & Davis, 2012). Closer access to piped water has also been found to be protective against diarrheal morbidity, and to reduce diarrheal illness duration (Thompson, 2001; Jalan & Ravallion, 2003). Further, close access to piped water, either in the home or compound, has been linked to an increase in the quantity of water consumed (Devoto et al., 2011; Thompson, 2001), and increased water consumption has been shown to be protective against diarrheal disease (Shrestha et al., 2013).

There is also considerable evidence to support the importance of improved sanitation on health (Fewtrell et al., 2005; Wolf et al., 2014). However, as nearly 88% of peri-urban households in Lusaka already have access to a pit latrine (CSO 2010), and the LWSSD Compact aims to facilitate household connection to the sewer system via a flush toilet, this review of the literature will be limited in scope to the health benefits associated with sewer-connected toilets. Sewer connections have been widely shown to decrease diarrhea; one meta-analysis found a 31% reduction in diarrheal morbidity among households with access to a toilet (Waddington et al., 2009). In addition, a meta-regression, though based on findings from only two studies, found a relative risk for diarrheal disease of 0.37 (95% CI: 0.31, 0.44) for sanitation interventions that provided a sewer-connected toilet where before there was an improved sanitation facility (for example, a latrine) (Wolf et al., 2014). Installations of sewer connections in large urban cities in Brazil and Iran also demonstrated a decrease in diarrheal prevalence; Barreto and colleagues found a decrease of 22% in Salvador, Brazil, while Kolahi et al. found diarrheal incidence to decrease by 9% in Tehran, Iran (Barreto et al., 2007; Kolahi et al., 2009). Furthermore, a study in peri-urban Lima, Peru, found the lack of a sewer connection to be associated with decreased child growth (Checkley et al., 2004). While considering these findings, it is important to note the studies are non-experimental in design and therefore there is a risk for confounding. Randomized, experimental interventions that provide sewer connections are few given the inherent cost of sanitation infrastructure and equity considerations. However, the studies presented, though limited in their study design, demonstrate the substantial health gains that can result from sewerage connections in urban areas.

In sub-Saharan African countries, the economic loss associated with inadequate access to water supply and sanitation is estimated to be 4.3% of annual GDP (Hutton, 2013). In Zambia, the

economic loss associated with inadequate sanitation alone is estimated to be 1.3% of the national GDP, an equivalent of approximately $194 million dollars. Nearly $180 million of that loss is attributed to premature death from WASH-related diarrhea, diarrheal disease-related healthcare costs, and productivity loss while sick with or accessing healthcare for diarrheal illness (Water and Sanitation Program, 2012).

2.13.1 Water Supply in Other African Countries

(a) South Africa

In South Africa, Water Supply is characterized by both achievements and challenges. At the end of apartheid, the government made strong commitment to high service standards and to high levels of investment subsidies to achieve those standards. Since then, the share of the population with access to an improved water source has increased from 83% in 1990 to 91% in 2010 (WHO/UNICEF, 2010). South Africa urban water supply sector generally performs better compared to the rural sector. According to the South African government data, urban water coverage is 96% and 99% according to Joint Monitoring Programme (JMP) data.

The Department of Water (DWA) in the Ministry of Water and Environmental Affairs is primarily responsible for the formulation and implementation of policy governing water resources management as well as drinking water supply while municipalities are responsible for service provision. The country's 231 municipalities are in charge of water distribution and sanitation either directly or indirectly through municipally owned enterprises or private companies; government-owned water boards are in charge of operating bulk water supply infrastructure and some wastewater systems; and the Trans-Caledon Tunnel Authority finances and develops dams and bulk water supply infrastructure (Republic of South Africa, Department of Water Affairs, 2009).

Despite the success scored, South Africa Department of water affairs and the municipalities still faces a number of challenges such as sound asset management, best practice network management, and appropriate pricing to ensure adequate maintenance, timely replacement of infrastructure, reduced nonrevenue water (water losses and unaccounted-for water), and wise and effective use of public resources. There is also lack of the implementation of a sound management development program for water managers.

In order to mitigate the challenges faced, South Africa has ensured that it has a strong research and training infrastructure in the water sector. The Water Research Commission (WRC) supports water research and development endeavors to build sustainable capacity in water research. The Water Institute of Southern Africa (WISA), a professional association, keeps its members abreast of the latest developments in water technology and research through its national and international liaison, links and affiliations (WISA, 2010). The government also involves financiers and promoters on its water projects as well as the civil society which comprises large numbers of NGOs with diverse structures and methods (Development Bank of Southern Africa, 2005-2006).

The recent low rainfall and drought conditions experienced in the past few years left eight out of nine provinces declared disaster areas. However, in Gauteng, the Johannesburg Water Department entered into partnership with the Borehole Water Association to encourage residents to use borehole water and mitigate the droughts and relieve pressure on surface water demands. A research revealed that a well-maintained borehole is also a cost-effective, self-sufficient asset. Although initial costs of drilling and equipping may be high, there are long-term financial benefits to groundwater, particularly the fact that borehole water costs significantly less than municipal water (Troskie & Johnstone, 2016).

(b) Nigeria

In Nigeria, three levels of government share the responsibility of water supply; these are the federal, the state and the local government. The federal government is in charge of water resources management; the state government has a primary responsibility for urban water supply and the local government with communities is responsible for rural water supply (Akpor & Muchie, 2011).

According to the WASH watch and the Joint Monitoring Programme statistics, 67% of the total population had access to basic water supply in 2015. This was 82% of the urban population and 54% of rural population. In the same year, around 60 million people lacked access to at least basic water (WASH, 2015).

From the statistics, it can be observed that access to improved drinking water in Nigeria is generally low, with urban areas having a higher portion than those in rural areas who have access. Between 1990 and 2008, the proportion of people with access to improved water supply

declined from 79% to 75% in urban areas and increased from 30% to 42% in rural areas. The decrease in urban areas was due to lack of services in peri and semi-peri urban areas as a result of rapid population growth. Unfortunately, this explosive growth of 5.0% per year and over concentration of people in urban areas has gone unchecked in Nigeria (WHO/UNICEF, 2015).

Overall, access to improved drinking water in Nigeria is generally low. There are a lot of factors to which these challenges can be attributed. According to Oluwabunmi Michael, these challenges include; poor funds management, government insincerity, inadequate information and education, land issues, artificial water scarcity and maintenance (Oluwabunmi, 2013). A survey conducted by WaterAid also noted fundamental weaknesses in the Nigerian water sector among which include among others; a lack of adequate planning data, capital intensive nature of the sector especially in the urban sector, low capacity of the key players, lack of policy framework at state level, lack of coordination and communication between players, and so on (ibid).

Most developing countries are faced with the challenge of how to supply safe drinking water to their citizens. In order to have effective water supply in Nigeria Akpor & Muchie recommended that there was need for enforceable water legislation, building of institutions and policies related to water resource planning, development and management, demand management and privatization of the water supply and distribution sector (Akpor & Muchie, 2011). They also stated that there was need to make sure that the ongoing water supply and distribution projects are completed, the groundwater reserves are completed, funds are provided, and adequate personnel are trained to cope with changing demands and technologies. Wateraid stated that there was need for greater clarity on roles and responsibility and greater integration of work across the three tiers of government, the federal government were also required to have an effective system for disbursement of government funds. There was need for better coordination in the sector, capacity development/utility reforms, community participation initiatives and development of state policies and the overall community involvement (Water Aid, 2016).

(c) Kenya

Low levels of access to water and sanitation characterises the water situation in Kenya and is more pronounced in urban slums and in rural areas (WASREB, 2009). This ultimately leads to poor service quality in the form of intermittent supply. The fact that Kenya is classified as a

chronically water scarce country which has less than 1000m^3 of fresh water available per person per year enhances this problem (Ministry of Water and Irrigation, 2006). According to the Joint Monitoring Programme (JMP), it is estimated that 58% of Kenyans (83% in urban areas and 50% in rural areas) had access to at least basic drinking water sources in 2015 (JMP, 2015). Twenty-two percent of Kenyans (45% in urban areas and 14% in rural areas) were reported as having access to piped water through house or yard connection. JMP also estimated that access to improved water sources in urban areas decreased from 92% in 1990 to 82% in 2015. However, in rural areas, access increased from 33% to 57% during the same period. The number of people lacking to at least basic water in 2015 was 19 million (WHO/UNICEF, 2015).

The Ministry of Water and Irrigation (MWI) is the key institution responsible for the water sector in Kenya. Due to sector reforms, the responsibility for water and sanitation provision has been devolved to eight regional Water Service Boards (WSBs). The WSBs are responsible for asset management that is for the development and rehabilitation of water and sewerage facilities, for investment planning and implementation (Ministry of Water and Irrigation, 2007). Responsibility for water and sanitation service provision is in the hands of WSBs. However, they are not required to deliver services directly; they can delegate them to commercially oriented public enterprise to the so-called Water Service Providers (WSPs). Service provision is regulated by Service Provision Agreements (SPAs) established by the Water Services Regulatory Board (WASREB).

Figure 2.6 shows the complexity of water sector in Kenya. It shows the involved institutions, layers of geographical interventions and competencies, and intersections between policy formulation, regulation and consumption of resource (Rampa, 2011).

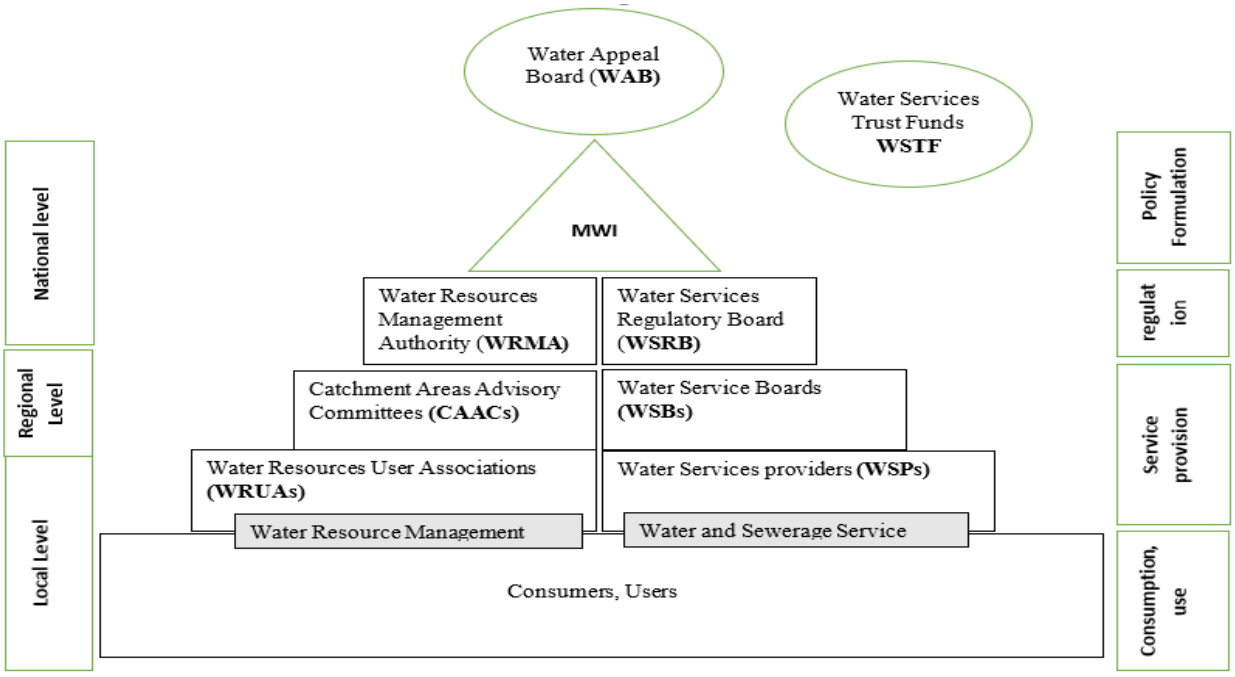

Figure 2. 6: Institutional set up under Water Act 2002. (Rampa, 2011*)*

According to Odira, Kenya faces a complex water resource crisis that is as a result of the following state of affairs; an extremely limited annual renewable fresh water resource per capita, a rapidly growing demand for water for multi-sectorial uses, on the one hand, and reduction of natural storage capacity and lack of development of artificial storage capacity and investment in other related water infrastructure to meet demand and to buffer against shocks. Sharing of over half of rivers, lakes and aquifers with neighboring countries is also a challenge in that it complicates management of these water resources with implications for regional security and development. The growing population has increased the demand for water for domestic use, food security and industrial development. Droughts recurrence is another challenge whose impact on water resources can be devastating (Odira, 2015).The other challenges being faced are due to poor technical, financial and commercial management WSS utilities. This is because these utilities cannot attract the right people or because the utilities lack conditions for proper commercial management. Therefore, these utilities are either run down or are operating below requirements due to poor Operation and Management. Institutions for water resources management generally lack qualified water resources engineers and planners. This is because staff without relevant experience was offloaded to these institutions from Ministry of Water & Irrigation.

In order to mitigate the various challenges in the water sector in Kenya, Odira recommended that the government adequately invests in capacity building of WSS and Water Resources Managers. He suggested the need to construct dams and pans and initiate groundwater recharge to increase water storage capacities. There is also a need to improve the efficiency of water resource management and consumption. He also endorsed increased capitation for development and conservation of water resources and environment. He also mentioned the enlarging of the existing sources of water with more sustainable alternatives such as rainwater harvesting and construction of storage infrastructure as well as water recycling and wastewater reuse (Odira, 2015).

In his water supply research for Kajiado Town, Mutuma identified the need for the county government to set aside adequate funds to carry out hydrological survey of areas with good potential for groundwater and drill wells and supply to supply 20% of water demand. Mutuma also recommended that the county government goes into partnership with the local community to develop shared catchment area protection and conservation plan (Mutuma, 2012).

2.13.2 Summary of lessons learnt.

This section reviews the literature on the management of the water sector in Zambia, South Africa, Nigeria and Kenya. The literature proves that the lack of improved water sources usually results in diarrhoea diseases which cause 760000 deaths among children under 5 every year.

It has been observed that rapid urbanization of major cities is a big issue because most of them lack the necessary water and infrastructure to support population growth. The water challenges being faced in most sub-Saharan Africa are very similar and are characterized by poor funds management, lack of maintenance of infrastructure, lack of coordination and communication between stakeholders, extremely limited annual renewable fresh water, lack of development of artificial storage capacity, droughts, and poor technical, financial and commercial management of WSS utilities.

One country that is seemingly succeeding in its endeavor to supply water to its burgeoning urban areas is South Africa. In the South African Operations Strategy for the water sector, we see that the water supply chains are shared by different entities as structured and documented in its water management policies.

South Africa has a strong research and training infrastructure which is managed by the Water Research Commission (WRC). The Water Institute of Southern Africa also keeps its members abreast with the latest development in water technology and research which the government actively involves financiers and promoters on water projects. South Africa has the Borehole Water Association (BWA) that encourages certain residents to be using properly regulated groundwater so as to relieve pressure on surface water demand.

The literature also proves that Operations Strategy through it principles and concepts is a tool that can be applied to most organisations including water utilities companies in setting up broad policies and clear plans on how the organisation can best utilize its resources to best support its long term business strategy.

One of the critical components in operations strategy lies in a firm's ability to be able to identify its core competencies that are crucial to the business strategy. As a result, more resources get dedicated to these priority areas and fewer resources are left for others. By so doing, the performance of practical work increases, and the resulting competencies enables the organisation to maximize its Net Present Value (NPV).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the description of methods applied in carrying out this study. It encompasses procedures that were followed to collect, analyze and interpret data in any study. It focuses on the research design, research site, population, sampling techniques, data collection instruments, data collection procedures and data analysis.

3.2 Research Design

The research employed a non-intervention research design, in particular, a descriptive design. This design was used because the investigation took an uncontrolled setting; Lusaka District in Lusaka Province of Zambia. The research adopted this design due to the fact that the findings of the research endeavoured to make descriptions based on actual events without undue influence of intervention whatsoever. This approach required the use of both qualitative and quantitative data to paint a full picture relating to the successes and failures of the factors that are associated with the cost and quality of water and water services in residential areas.

3.3 Study Setting

The study was conducted in Lusaka District, specifically; Chelstone Obama east of Lusaka, Libala and Chalala residential areas located south of the district. Chelstone Obama and Chalala areas were chosen based on being the new residential areas which are yet to be connected by LWSC and thus depend on boreholes as their main source of water. Libala was chosen because of being one of the already piped areas by LWSC that is thought to be experiencing a favorable water supply service. The study also observed the water issues and challenges that households in other areas such as Avondale, PHI, Fairview etc. had. Figure 3.1 in the next page is the map of Lusaka district that clearly illustrates the main study sites.

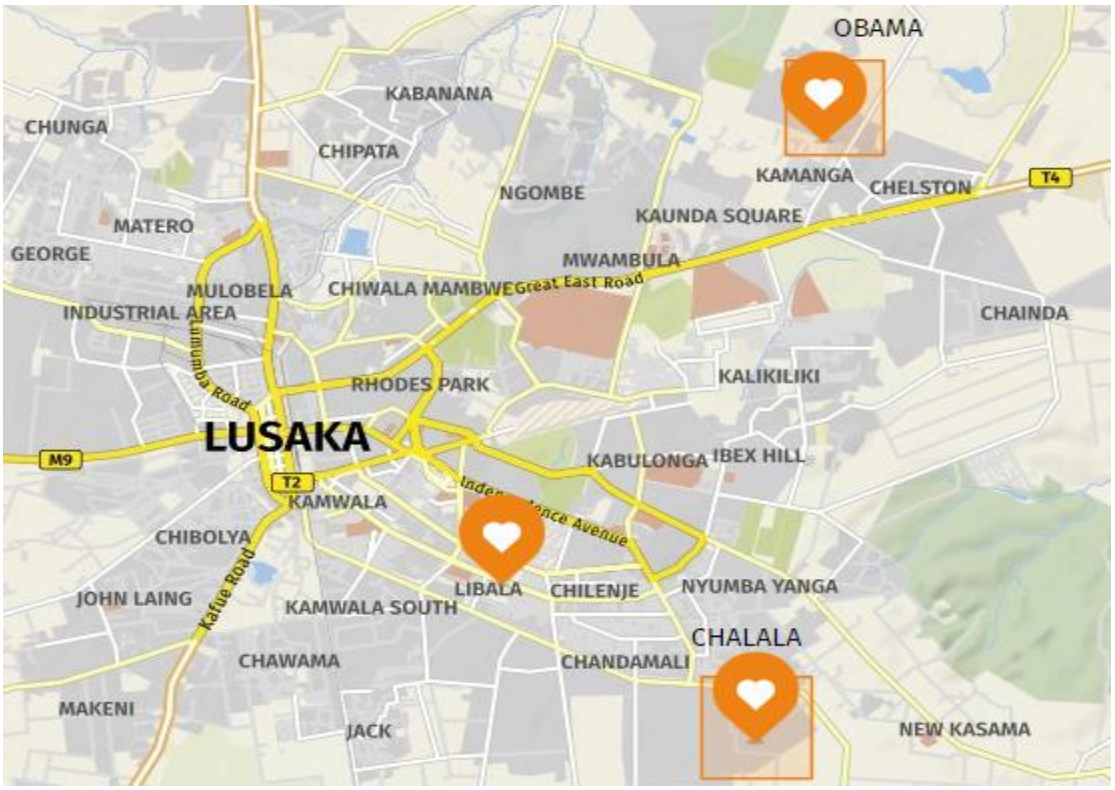

Figure 3. 1: Map of Lusaka district highlighting study sites.(source: www.mapz.com)

3.4 Sampling Procedures and Sample Size

The population of households in the study areas was estimated to be over 3000. A sample of 30 was targeted from each chosen cluster location. Sample size was calculated using equation 1 below:

$$n = \frac{8(CV)^2}{(PC)^2}[1 + (1 - PC)^2] \quad \text{..... (1)}$$

Where, n= sample size, PC is proportionate change in mean, CV is coefficient of variation. PC was taken to be 20% and CV was taken to be 30 %. From these values, sample size was found to be approximately **30** (Belle & Millard, 1998).

Sample size was based on the Central Limit Theorem which states that if you have a population with mean μ and standard deviation σ and take sufficiently large random samples from the

population with replacement, then the distribution of the sample means will be approximately normally distributed. This will hold true regardless of whether the source population is normal or skewed, provided the sample size is sufficiently large (usually $n \geq 30$) (University of Boston, 2016).

The survey used a three-stage stratified cluster sample design, with residential areas selected during first stage, and clusters within residential areas selected during the second stage and households to be selected at third stage. Stratification was achieved by separating the residential areas into categories. In each classification, probability proportional to size of the residential area was used to determine the number of households to be selected in those areas. Upon obtaining and creating the list of eligible clusters, the optimal distribution of household was determined to minimize field costs and still ensure representativeness.

Households were then sampled randomly and purposively. This means that the study targeted a group of households believed to be reliable for the study. If the chosen house failed to give response, the next house was included. This technic can be carried out in addition to probability sampling and is particularly relevant when a study is concerned with exploring the universe and understanding the audience. Purposive sampling can be used with both quantitative and qualitative studies. (Kombo and Tromp, 2006). Furthermore, the study also collected qualitative data from a key informant from Lusaka water and Sewerage Company.

In addition, two (2) water samples were collected from each of the residential areas selected to measure the water quality.

3.5 Nature and Sources of Data

The nature of the data was both quantitative and qualitative. The sources of data were primary and secondary

(a) Primary Data

Primary data usually refers to the data that is collected by the researcher directly from the respondent. The two main types of instruments used in the collection of this data were structured

questionnaires and interview guides. An observation technique was also used as a means of collecting primary data. Water samples from each location under investigation were collected using sterilized bottles.

(b) Secondary Data

This involved collection and analysis of published materials, and information from internal source. The main source of secondary data was the company website and publications such as water sector news articles and reports and other electronically stored information. The advantage of the secondary was that it was available more cheaply and was significantly quicker and easier than collecting data from scratch.

3.6 Data Collection Instruments

The study employed household questionnaires, the interview guide, observation and sterilized water sampling bottles.

(a) Questionnaires

The questionnaires were administered to households in the study areas. These questionnaires were designed to ascertain the current household water supply source and services and also the consumer perception of the service being rendered by LWSC in terms of cost, time, quality and flexibility. The main questions in the questionnaire were closed or structure. However, few open-ended questions were included to allow respondents to give detail. Appendix 1 shows sample of questionnaire used. The questionnaire was mostly quantitative in nature.

(b) Interview Guide

The interview guide shown in Appendix 2 was used to conduct an interview with the assigned key informant from LWSC. This was merely a guide for the researcher on the kind of information sought from the interviewee. Since the responses were mostly descriptive in nature, the interview guide mainly collected qualitative data.

(c) Observation

The observation technique was also used as a tool for collecting primary data. Using this, the researcher physically obtained data through the observing of different queries and issues that consumers in other residential areas had.

3.7 Data Analysis

The collected data was analyzed both quantitatively as well as qualitatively. The quantitative data obtained from primary sources was analysed using mathematical, statistical and computational methods. Data entry was done using a statistical software package called Epi Data. Qualitative data was analysed descriptively and thematically. Water samples were analysed using water quality analysis laboratory methods.

(a) Quantitative Data Analysis Software

EpiData Entry is used for simple or programmed data entry and data documentation. It handles simple forms or related systems, optimized documentation and error detection features (Epidata Software, 2013). Analysis of data was done using Stata. This software was chosen because not only is it user friendly, but also can perform vast and in-depth analysis. Results produced from Stata were copied and pasted in MS Excel for editing and designing of graphs, pie charts and tables, thereafter, to MS Word for report writing.

(b) Thematic Analysis

Thematic analysis was used to analyze data that was collected from the interview with the Key informant and also data collected from other secondary source. Braun and Clarke (2006) define thematic analysis as, “A method for identifying, analyzing and reporting patterns within data.” Thematic analysis is a widely used method of analysis in qualitative research. In 2006 Braun and Clarke published an article that described to novice researchers how to use thematic analysis in a step-by-step manner. Thematic analysis is a foundational method of analysis that needed to be defined and described to solidify its place in qualitative research.

Thematic analysis is simple to use which lends itself to use for novice researchers who are unfamiliar with more complex types of qualitative analysis. It allows for flexibility in the

researcher's choice of theoretical framework. Some other methods of analysis are closely tied to specific theories, but thematic analysis can be used with any theory the researcher chooses. Through this flexibility, thematic analysis allows for rich, detailed and complex description of your data (ibid).

3.8 Analysis of Water Samples

(a) Level of pollution analysis using Pollution Index (Pi)

The study used the Pollution Index to show the level of pollution of borehole and tap water by each parameter. Pollution index (Pi) according to Akpoveta *et al.* (2011) is expressed as a function of the concentration of individual parameter values against the baseline standard (WHO permissible value). It is given by the equation 2 below:

Pollution index (Pi) = Concentration/ Standard ……. (2)

The statistical significance of pollution will then be affirmed by T test one sample analysis, to compare each parameter value with the WHO permissible standard for drinking water (WHO, 1985).

3.9 Limitations of the study

The subject of operation strategy is quite broad. However, it was noticed that there weren't enough studies done previously in relation to public service delivery. Therefore, difficulties in generalizing the information collected were experienced. Also, most of the qualitative data collected from LWSC was self-reported and was not independently verified.

3.10 Ethical Considerations

This study was safe for all sets of respondents. By being in the study, the respondents never suffered any harm or injury. Verbal consent was obtained from the respondent upon explaining the purpose of the study and how the results will be utilized. Area residents were also reminded that participation in this study was voluntary and respondents were free not to complete the survey without any penalty and remove any data that they have contributed. The respondents were assured that at no time was their name going to be reported along with any responses.

Anonymity of respondents was assured; all respondents were only identified by code numbers and information collected was held in confidence. Additionally, permission was also sort from the Lusaka Water and Sewerage Company before the study took off (see Appendix 3).

CHAPTER FOUR

RESEARCH FINDINGS

4.1 Introduction

This chapter presents findings from the survey carried out to assess the water consumers past experiences, water consumers personal needs, financial capabilities, expected and availability of service and quality of water sources and the water product itself. The chapter also presents findings with regards to LWSC management capacity, capabilities, management perception of consumer needs, challenges and strategies put in place to meet these needs and challenges.

4.2 Background Characteristics of respondents and households

Table 4. 1: Background Characteristics of Respondents from households

Respondent's characteristics	**Percentage of respondents**
Age Group	
15-24	16.7
25-34	27.8
35-44	28.9
45-54	16.7
55+	10.0
Total	*100.0*
Sex	
Male	44.4
Female	55.6
Total	*100.0*
Highest education level	
No education	3.3
Primary	12.2
Secondary	34.4
Tertiary	50.0
Total	*100.0*

Table 4.1 shows the background characteristics of individual household respondents. The total number of respondents from households was ninety (90). Twenty nine percent (29%) were in the age group 35-44 followed by 28% in age group 25-34. The age groups 15-24 and 45-54 had the same number of respondents, 17% each. With regards to sex, majority (56%) were females while 44% were male. Further, about 5 per 10 respondents from households (50%) had attained tertiary education followed by 34% who attained up to secondary education. Respondents who attained primary education made up 12% of the sample and only 3% had no education at all.

Table 4. 2: Household Characteristics

Household characteristics	**Percentage of respondents**
Length of Stay at Current Home	
0-1 years	14.4
1-2 years	22.2
2-3 years	18.9
3-4 years	17.8
4-5 years	7.8
5+ years	18.9
Total	*100.0*
Number of Household Members	
1-5	33.3
6-10	54.4
11-16	12.2
Total	*100.0*
Mean = 7, Min = 3, Max = 16	
Source of Water	
Borehole/Well	61.1
Tap/Piped Water	38.9
Total	*100.0*
Location of Household	
Libala	33.3
Chelstone Obama	33.3
Chalala	33.3
Total	*100.0*

Table 4.2 shows the characteristics of households sampled. The length of staying at current home indicated that 22% of respondents had stayed at their home between 1 and 2 years. Those who stayed between 2 and 3 years, and 5 years and over, accounted for 19% of the respondents. Eighteen per cent had stayed at their current home between 3 and 4 years while 14% had been there for less than a year. The lowest percentage (8%) was among those who had been in their home between 4 and 5 years.

The average number of household size was 7 members, while the minimum was 3 and maximum 16 household members. However, slightly over half (54%) of respondents had between 6 and 10 members of the household. Above a quarter (33%) had between 1 and 5 members of the household and 12% had between 11 and 16 members.

With regards to sources of water, majority of households (61%) got their water from boreholes while the remaining 39% had piped water. These households were from three locations within Lusaka district, namely; Libala South, Chelstone Obama and Chalala (each represented by 33% of the households).

4.3 Results for Households with Boreholes

Table 4. 3: Cost drilling and installing borehole unit

Cost of installing Borehole Unit	Percentage of boreholes
<K10,000	10.9
K10,000-K19,999	41.8
K20,000-K29,999	29.1
K30,000+	3.6
No Response	14.6
Total	100.0

Table 4.3 shows the cost expended in drilling and installing borehole units by households with boreholes. With regards to cost of installing borehole unit, 42% of respondents reported that it costed them between K10,000 and K19,999 followed by 29% who reported that the cost was

between K20,000 and K29,999. Eleven per cent reported that the cost of installing borehole unit was less than K10,000. The average cost of installing a borehole unit was K17,425.

Table 4. 4: Borehole ever needed repairs

Borehole ever needed repairs?	**Percentage of boreholes**
Yes	38.2
No	60.0
No Response	1.8
Total	*100.0*
Was borehole repaired?	**Percent**
Yes	100.0
Total	*100.0*

Table 4.4 above shows the number of households that had done repair works on their borehole. There were 38% of households whose boreholes needed repairs at some point while over half of the households (60%) did not encounter a malfunction of their borehole to require repairs. All of the households whose boreholes ever needed repairs had them fixed.

Table 4. 5: Cost of repairing borehole

Cost of borehole Repair (zmk)	**Percentage of respondents citing the cost**	**Measure of Central Tendency**
500	4.8	
1000	4.8	*Mean = K1,819*
1200	14.3	
1500	19.1	*Min = K500*
1800	9.5	
2000	33.3	*Max = K3,500*
3000	9.5	
3500	4.8	
Total	*100.0*	

Table 4.5 shows how much it had cost to repair the boreholes that had once broken down 35% of households with boreholes had repaired the boreholes before. The average cost of repairing the borehole among households was K1,819. The minimum cost was K500 and maximum was K3,500. Noticeably, 33% of households repaired their boreholes at K2, 000 followed by 14% who had them repaired at a cost of K1, 500.

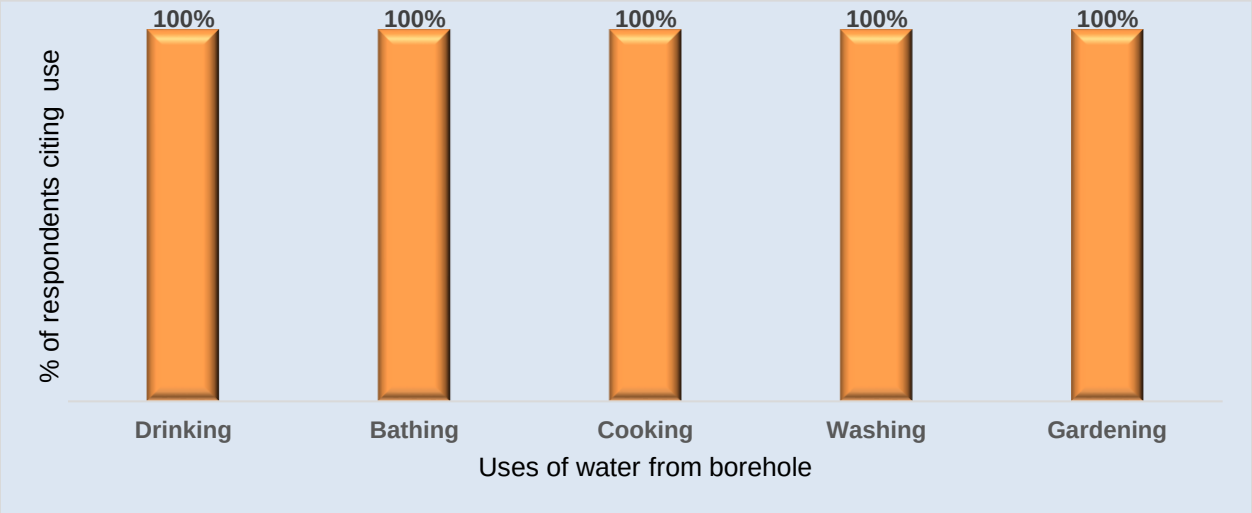

Figure 4. 1: Uses of water from borehole

Figure 4.1 above shows what the respondents used the water for. The uses of water from boreholes among households include; drinking, bathing, cooking, washing and gardening. All of these uses were reported by respondents. There were no other uses reported under the provision where respondents were asked to specify any other use.

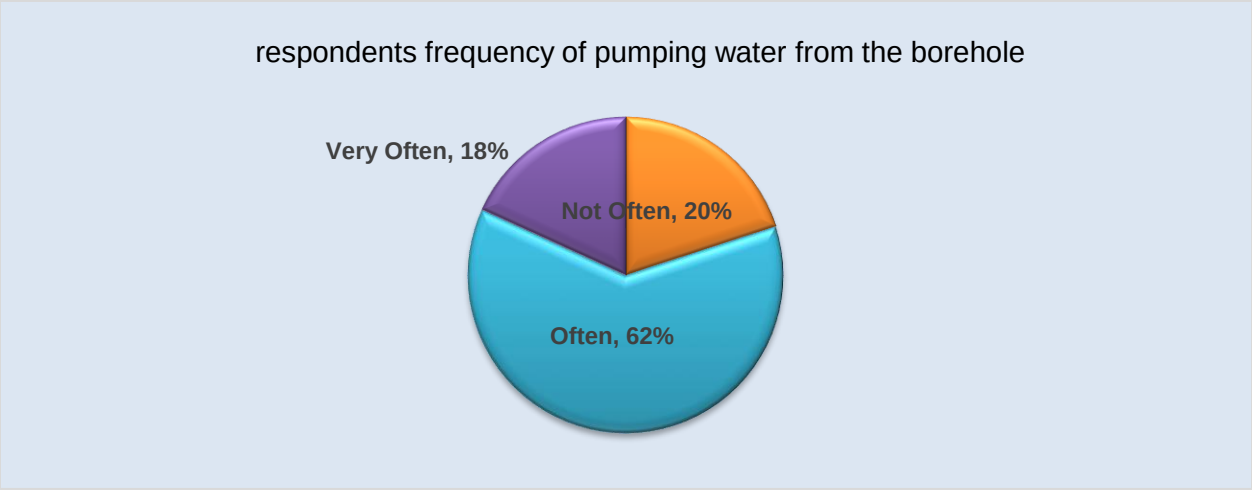

Figure 4. 2: Frequency of pumping water from borehole

Figure 4.2 shows the frequency of pumping water from boreholes by the respondents. About 6 per 10 households (62%) pumped water from the boreholes often, 20% did not often pump water while 18% pumped water from their borehole very often.

Table 4. 6: Distance between borehole pump and soak away

Distance between soak away and borehole pump (in meters)	**Percentage of households**	**Measures of central tendency**
2	3.6	
3	12.7	Mean = 7.6
4	5.5	
5	23.6	Min = 2
6	7.3	
7	5.5	Max = 20
8	5.5	
9	1.8	
10	20.0	
14	1.8	
15	9.1	
20	3.6	
Total	100.0	

Table 4.6 shows the distance between borehole pump and soakaway. The average distance between soak away and borehole pump was 7.6 meters. The lowest reported distance was 2 meters while the maximum distance was 20 meters. Almost a quarter (24%) of the respondents reported that the soak away and borehole pump were 5 meters apart followed by 20% who reported that they were 10 meters apart. This was then followed by 13% of respondents who reported that the distance between the soak away and borehole pump was 3 meters.

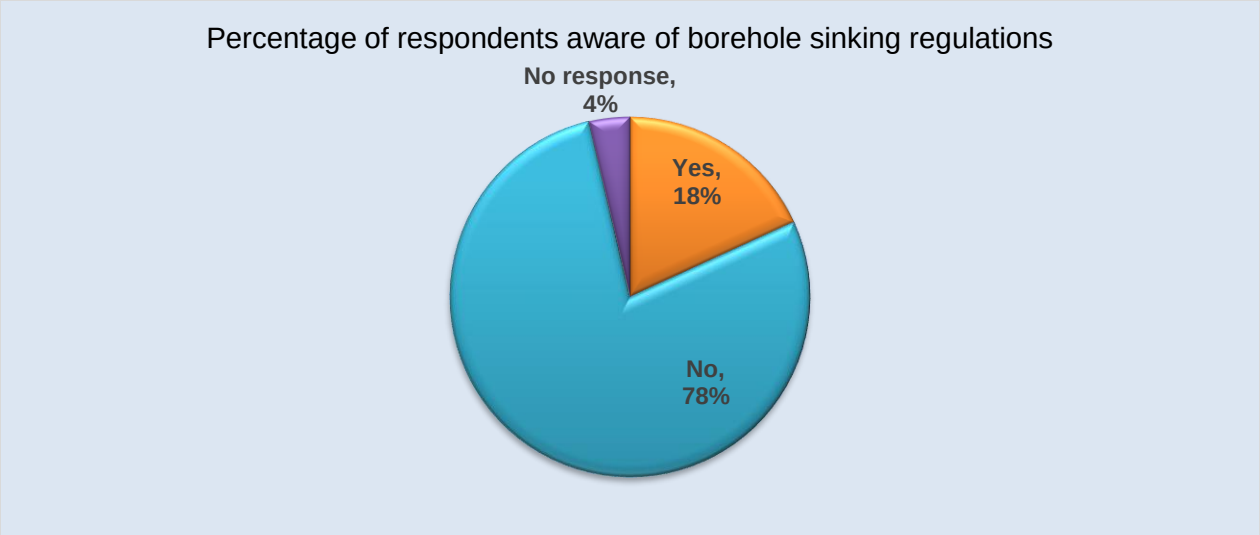

Figure 4. 3: Awareness of regulations for sinking boreholes

Figure 4.3 shows the levels of awareness of regulations for sinking boreholes. Majority of respondents, 78% from households with boreholes were not aware of the regulations for sinking boreholes. Only 18% knew of the regulations. The remaining 4% of respondents did not respond to the question.

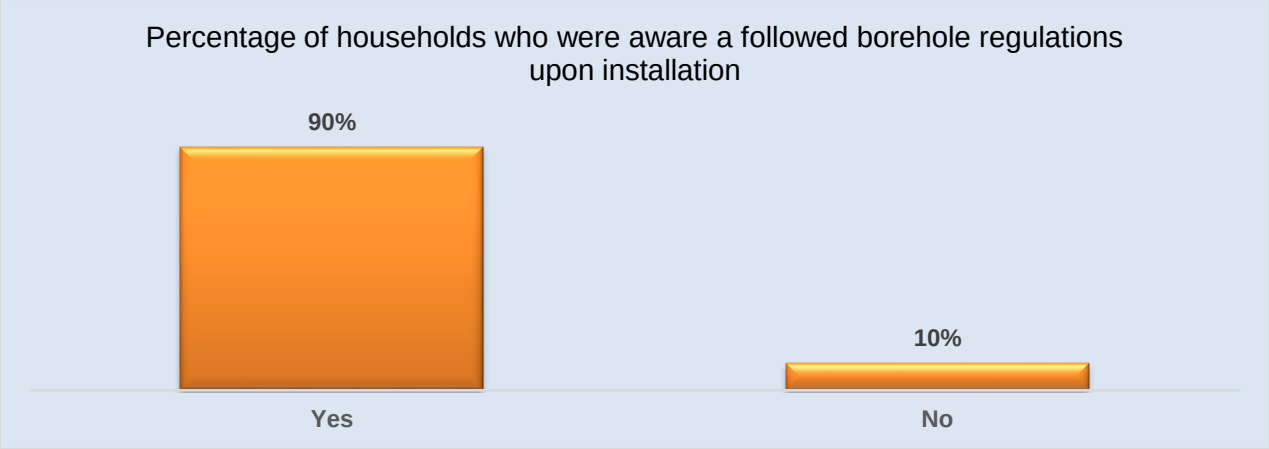

Figure 4. 4: Following regulations for sinking boreholes

Figure 4.4 indicates the number of households that were aware of borehole regulations and were actually following them. The respondents who were aware of the regulations were further asked

whether or not these regulations were followed when sinking the borehole at their household. 90% reported that the regulations were followed while 10% said they were not followed.

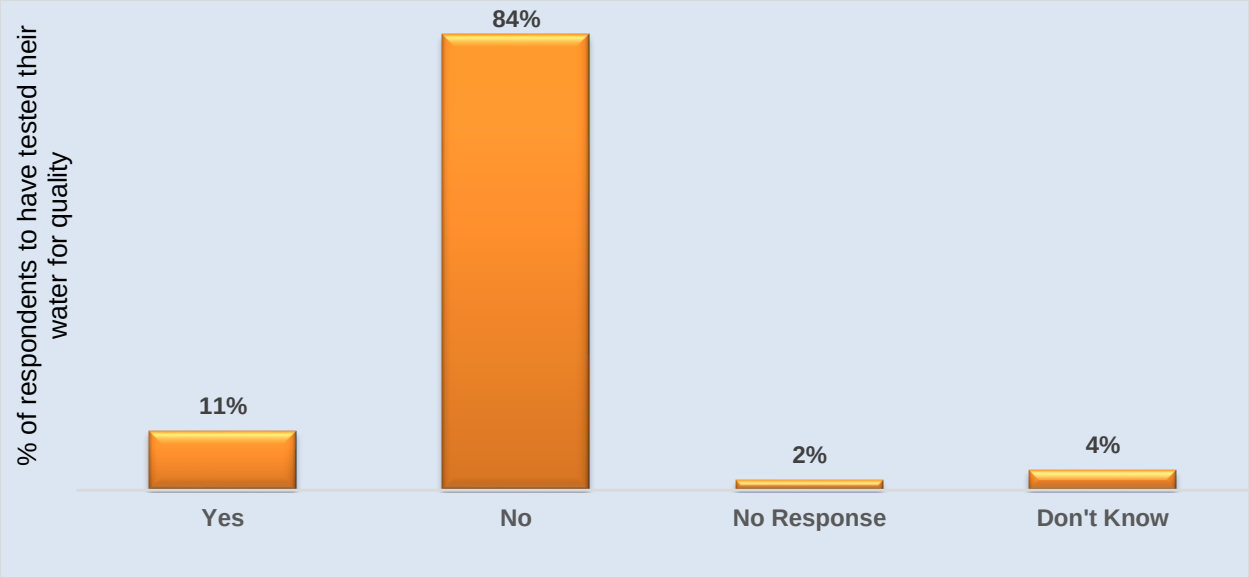

Figure 4. 5 : Testing water for quality

Figure 4.5 shows the number of households who had taken a step to test their borehole water for quality. A majority 84% of households had never tested their water for quality. Only 11% of the households reported that they had tested their water for quality. Out of the 6 households whose water was tested for quality, 4 (67%) conducted the test at home while 2 (33%) carried out the test at a lab.

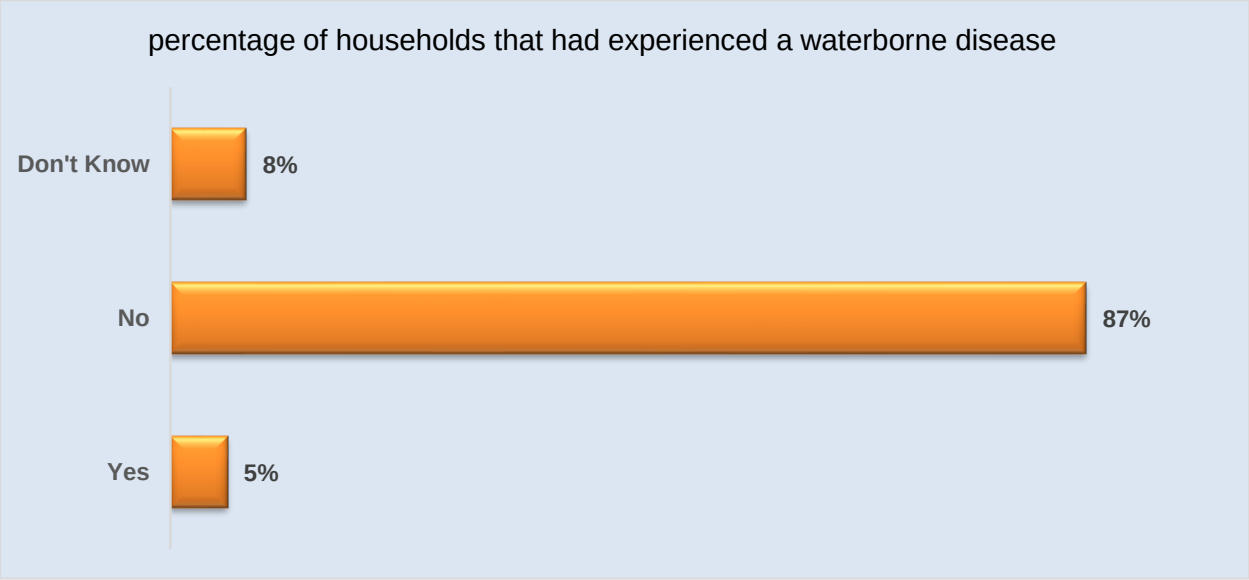

Figure 4. 6: Anyone ever suffered from diseases suspected to be waterborne

Figure 4.6 shows the number of households that had a member suffer from a disease that was suspected to be waterborne. 87% of the households reported that no one had ever suffered from a disease suspected to be waterborne. However, 5% reported that there was an occurrence of diseases suspected to be waterborne. This disease in particular was diarrhea.

4.4 Results for Households with piped water

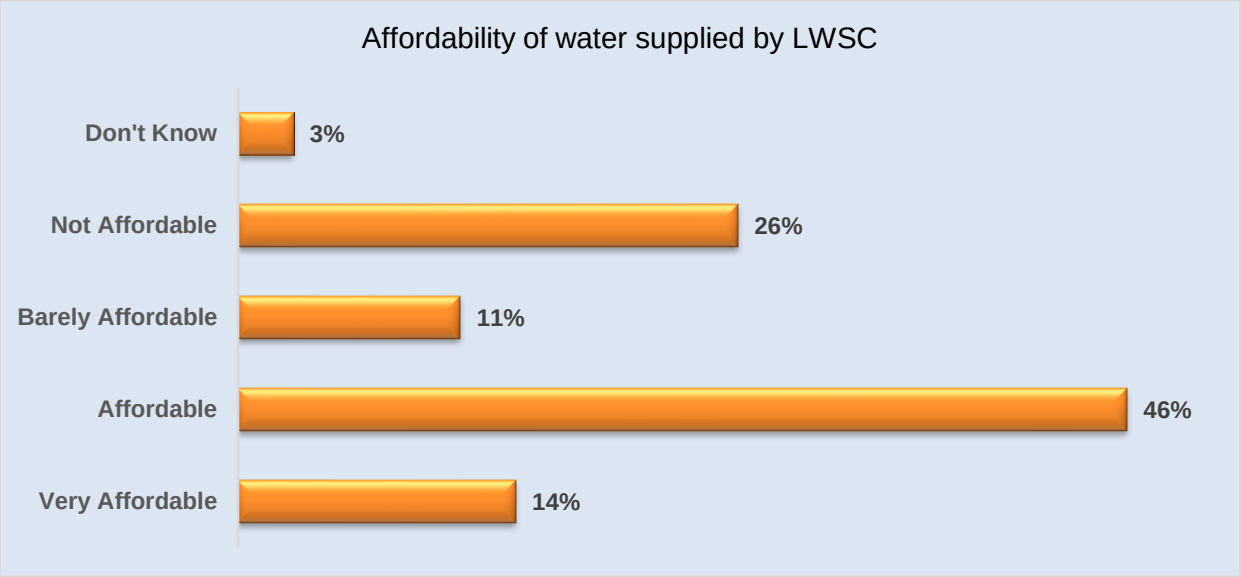

Figure 4. 7: Affordability of water supplied by LWSC

Figure 4.7 shows the affordability of water supplied by LWSC. Nearly half 46%, of respondents from households with piped water reported that the water supplied by LWSC was affordable and 14% reported that it was very affordable. Slightly above a quarter (26%) mentioned that the water was not affordable while 11% reported that it was barely affordable.

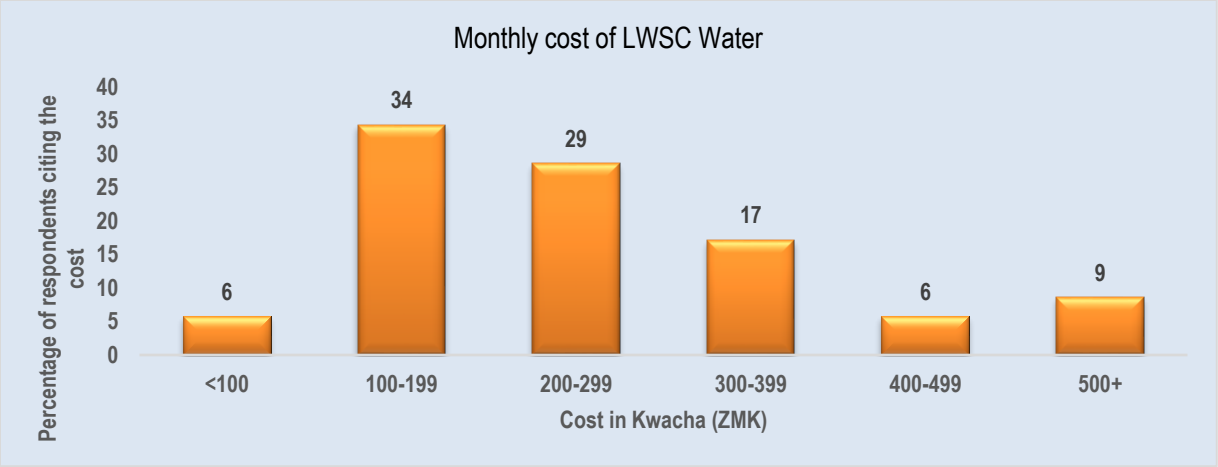

Figure 4. 8: Monthly cost of LWSC water

Figure 4.8 shows how much respondents spent on LWSC water per month. Most of the respondents (34%) reported that they paid between K100 and K199 kwacha per month for water bills, followed by 29% who reported that they paid between K200 and K299. 17% paid between K300 and K399 while 9% paid K500 and above. Those who paid less than K100 and between K400 and K499 each accounted for 6% of the respondents.

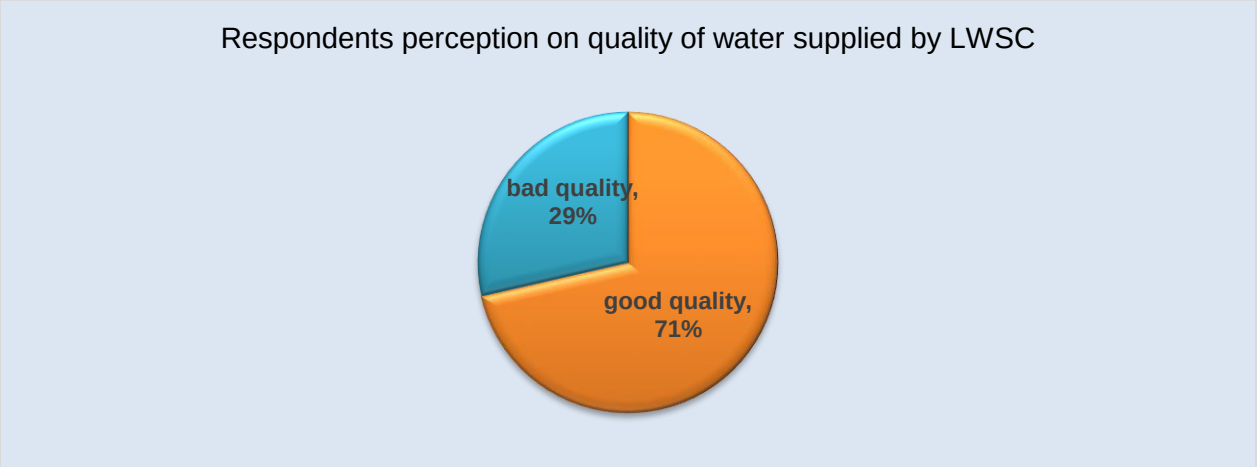

Figure 4. 9: Respondents' perception on quality of water

Figure 4.9 shows the respondents perception on the quality of water. Respondents were asked whether they thought water supplied by LWSC was of good quality and almost three quarters

(71%) reported that they thought it was of good quality. The remaining 29% reported that they thought the water was not of good quality.

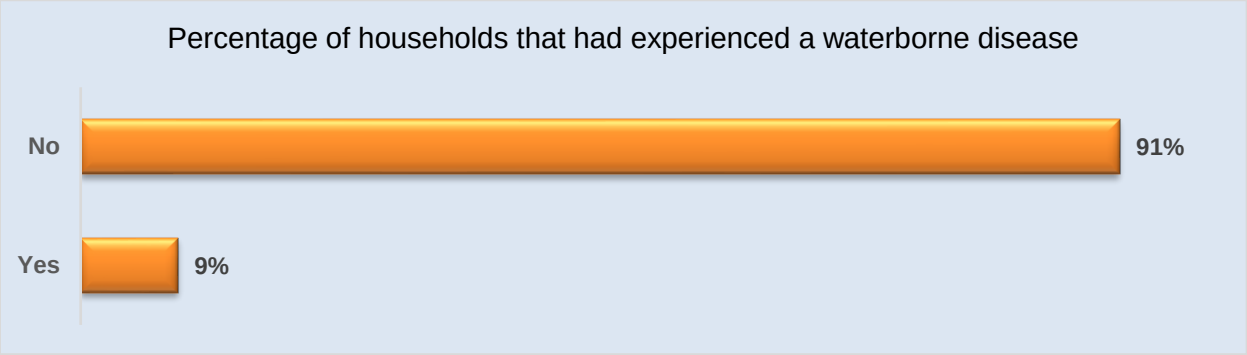

Figure 4. 10: Anyone ever suffered from diseases suspected to be waterborne

Figure 4.10 shows the number of household that had a member suffer from a disease that was suspected to be waterborne. 91% reported that no one had suffered from a disease suspected to be waterborne and 9% reported that someone had a disease suspected to be waterborne. The disease in question was diarrhoea.

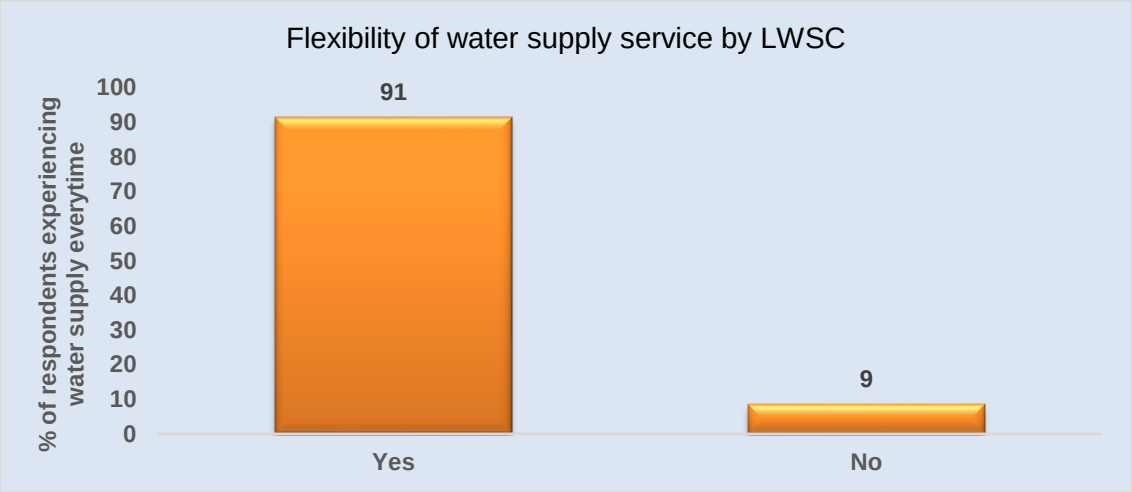

Figure 4. 11: LWSC supplying water every time of the day or night

Figure 4.11 shows how often LWSC supplied water to respondents household. 91% of respondents reported that LWSC supplied them with water every time of the day or night while 9% said that was not the case.

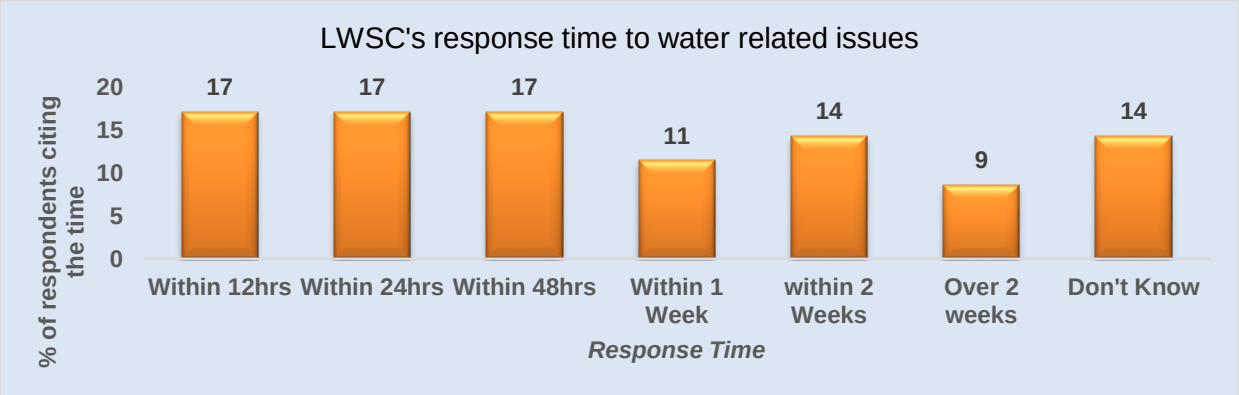

Figure 4. 12: LWSC's response time to water related problems

Figure 4.12 shows LWSC response time to water related problems. The response periods of within 12 hours, within 24 hours and within 48 hours were each reported by 17% of the respondents. This was followed by 14% of respondents who reported that LWSC responded within 2 weeks after being notified (same number as respondents who did not know the time LWSC would take to respond). 11% said LWSC would respond within a week after being notified and 9% mentioned that LWSC would take over 2 weeks.

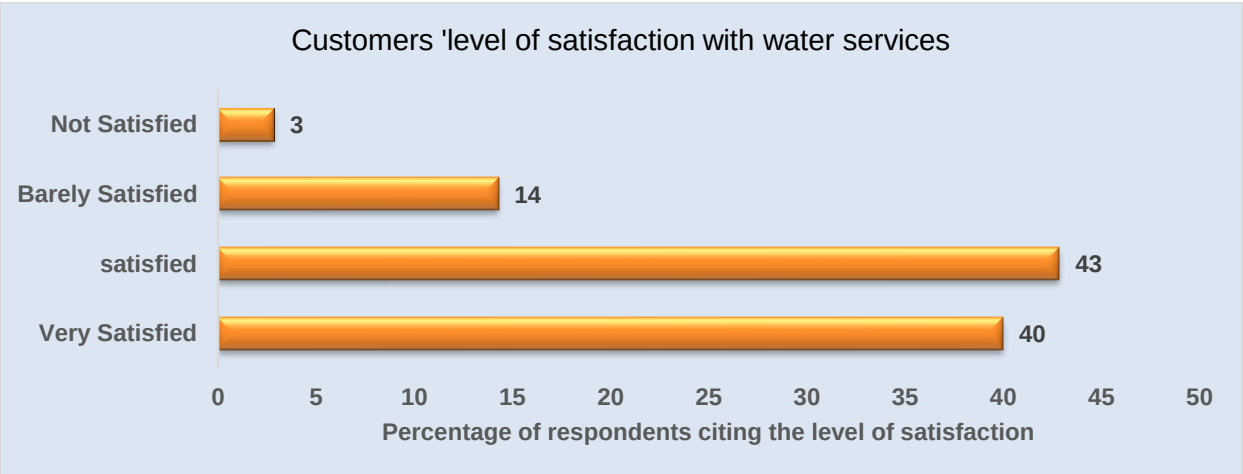

Figure 4. 13: Customers' level of satisfaction with water services offered by LWSC

Figure 4.13 shows customers' level of satisfaction with water services offered by LWSC. Majority of respondents were satisfied with water services offered by LWSC. This was indicated by 43% who reported that they were satisfied and 40% who were very satisfied. 14% were barley satisfied and 3% were not satisfied at all.

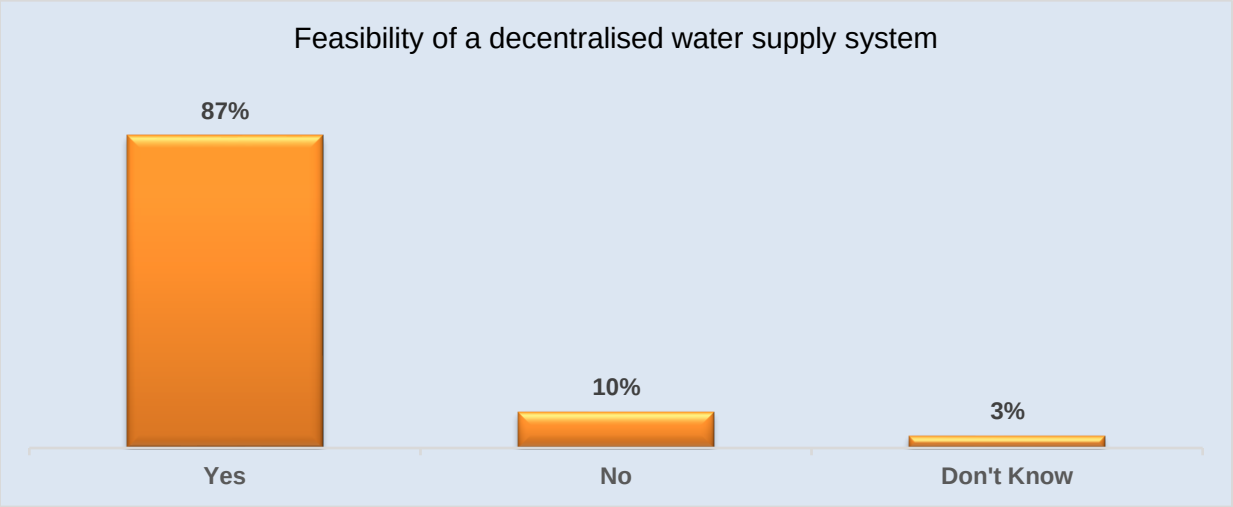

Figure 4. 14: Decentralised water supply system

Figure 4.14 shows the response of respondents from both households with boreholes and those with piped water who were asked whether they thought having a decentralized water supply system for new residential areas was a good idea. Over three quarters (87%) reported that a decentralized water supply system was a good idea while 10% reported that it was not a good idea. Only 3% did not know whether it was a good idea or not.

4.5 Physical, Chemical and Microbiological quality of water supplied in the selected residential areas.

Two water samples were taken randomly from each selected locations; Chalala, Libala and Chelstone Obama. These samples were analyzed physically, chemically and microbiologically and then compared to the World Health Organization (WHO) standards. The borehole water from both Chalala and Chelstone Obama tested positive to high levels of total and feacal coliform bacteria and generally had high turbidity levels. Piped water supplied by LWSC in Libala was void of total and feacal coliforms but also had high turbidity levels. The rest of the

parameters were well within the prescribed WHO guidelines for maximum permissible value for drinking water. Table 4.7 shows the results for Physical and Bacteriological tests (See Appendix 4 for detailed results).

Table 4. 7: Results for Physical and bacteriological test of water

Parameter	**Sample 1 Chalala Salena**	**Sample 2 Chalala Salena**	**Sample 3 Libala Stage 3**	**Sample 4 Libala Stage 3**	**Sample 5 Chelstone Obama**	**Sample 6 Chelstone Obama**	WHO Guideline(Maximum Permissible Value for drinking water)
pH	6.90	6.98	7.03	6.97	6.07	6.97	6.5-8.5
Turbidity (NTU)	4.76	8.96	9.57	8.41	12.8	9.14	5.0
Conductivity(µS/ cm)	681	358	328	336	416	910	1500
Total Dissolved Solids(mg/l)	354	184	168	173	215	483	1200
Bacteriological Results							
Total coliforms (#/100ml)	95	98	0	0	TNTC	80	0
Feacal coliform (#/100ml)	80	70	0	0	TNTC	70	0

Tests carried out in conformity with "Standard Methods for Examination of water and Wastewater ALHA, 1998."

4.6 Results from the Management Interview and secondary sources

4.6.1 Institution Framework

The findings about Lusaka Water and Sewerage Company's institutional framework with regards to operations strategies were as follows;

1. No clear institutional framework or policy for monitoring the quality, cost and time of delivery of water services in the uprising residential areas of Lusaka.
2. However, overall institution framework is based on the legislative framework which shows the key players in the water sector and the laws that governs the establishment of LWSC.
3. There are water service standards that are followed as stipulated by the regulator National Water and Sanitation Council (NWASCO).
4. The monitoring in households is done through watch groups formulated by the regulator NWASCO.

4.6.2 Rating of Operational Core Competencies

The LWSC's core competencies results were as follows;

1. **Quality**: Lusaka Water and Sewerage Company is always meeting the set guidelines for safe drinking water.
2. **Cost**: Cost of water is set by the regulator and is generally good for the consumer.
3. **Flexibility**: Flexibility in terms of water supply is not so good.
4. **Time**: Due to lack of materials sometimes, the time competence is not always met.

4.6.3 Challenges in connecting new residential areas

The following were the challenges that LWSC faces in connecting new residential areas;

1. The main challenge for Lusaka Water and Sewerage Company is capacity in terms of water versus the demand. The current capacity is barely meeting the demand. Demand is higher than the production capacity
2. Lack of sufficient operational materials is also a challenge.

3. There is too much reactive maintenance because of the Aged infrastructure, some of which is over 40 years old. Therefore, there is little time to look in new areas.
4. Limited investment in infrastructure renewal and expansion.
5. Cost of infrastructure cannot be financed from prevailing water tariffs.

4.6.4 Strategies put in place to address the challenges

The main strategy that Lusaka Water and Sewerage Company have to address the challenges is the Lusaka Water Supply Investment Master Plan. The plan outlines the following;

1. The necessary increase in design capacity
2. Addresses tailored extension of the distribution networks and the required increase of storage capacity in the network for the various horizons presented within.
3. The necessary investments also take into account projected improvements regarding non-revenue water, future urban developments, and a balanced scorecard for LWSC.

So far under the Millennium Challenge Account networks are being extended to Ndeke and Kwamwena through use of decentralized boreholes. The Kafue bulk project (150m dollar project) is also underway and will in an addition of 50000m^3 per day into Lusaka.
Ultimately the objectives of the master plan are to attain:

1. 100% access to safe water by 2035.
2. 80% access by house connection in 2035(from the current 35%).

Other strategies for mitigating the challenges being faced are laid out in LWSC Strategic Plan 2014-2018. Among the strategies are;

1. Improve efficiencies in the control and repair of leaks (Burst pipes)
2. Develop and implement water safety plan
3. Utilise underground water resource model
4. Construction of new water resources
5. Reduction of water production and transmission losses
6. To reduce energy cost per cubic meter of water produced
7. Implement asset management policy

4.6.5 Borehole Operations and Decentralization Considerations

The following discoveries on LWSC's borehole operations and decentralization considerations were made;

1. Lusaka Water and Sewerage Company currently operate just over 100 boreholes.
2. Almost half of the water is supplied in Lusaka comes from boreholes.
3. Considerations to decentralize borehole operations are still there as seen in the case of Meanwood Ndeke and Kwamwena. However, boreholes are not sustainable and are very fast becoming unreliable.
4. The general direction is for water to come from surface source, for example Kafue river
5. Boreholes will only be considered where there is no opportunity or chance to connect using surface water.

4.6.6 Resources needed to connect the uprising residential areas.

The main resources that LWSC needs to connect the uprising residential areas are as follows;

1. Designs for distribution networks
2. Monetary resources (from funders and partners)
3. Materials for network construction, such as pipes, pumps, valves reservoirs and so on.
4. Water resource would be the main resource.

4.6.7 Plans to work with real estate stakeholders

1. Plans to work with real estate stakeholders are already in place.
2. Roma Park is a good example where real estate providers have developed an area with all water networks in them and then handed over the operations to LWSC.
3. Sometimes real estate providers will solicit guidance in construction phase and then hand over to LWSC after full installation.

4.6.8 Room for Subcontracting

1. Subcontracting can work but might bring about its own disadvantages in service provisions. This is because if one side slacks, the blame can fall on one party who might not even be the cause of the slack.

4.6.9 Key Competencies to nature

The following are the competencies that LWSC needs to focus on for improved service delivery;

1. **Time**: This can be done through Asset Management which will need to Lusaka Water and Sewerage Company getting to properly know their assets and the condition of those assets.
2. **Cost**: For the competence of cost to be a real competitive advantage for LWSC, a case should be made with the regulator to balance the price of water.

4.6.10 Ways of improving the governance and delivery of water service in the uprising residential areas

1. Improvement can be made through favorable policies by the government and the sector regulator.

4.7 Results from Observation

During the research, it was that observed there was continuous supply of piped water by LWSC in Kabwata, Libala, Ridgeway and some parts of Chilenje. There was also good supply in Kamwala south which is one of the areas recently connected by LWSC. However, other areas of Lusaka like PHI, Avondale, Chelstone, Fairview and Olympia have challenges where continuous supply of water is concerned. In some parts of Avondale and Chelstone, it has even become so erratic to the extent that residents are now constructing their own storage erecting tanks as means of mitigating the water deficit.

Residents in Chalala, Chelstone and Meanwood Ibex had no piped supply and every household got its water supply from borehole.

4.8 How can LWSC improve its governance and delivery of its water services-Residents view?

Table 4.8 shows the derived themes of the suggestions that were made by respondents on how LWSC can improve its governance and delivery of its water services. More light is shed on these suggestions in the next chapter under discussions.

Table 4. 8: Themes on how LWSC can improve governance and delivery of water services

Suggestions on how LWSC can improve governance and delivery of water services	**Number of interviewees who cited this reason**	**Percentage of interviewees who cited this reason**
Derived Themes		
Tap and borehole installation	13	13
Reduce tariffs	12	12
Notification	12	12
Customer Services	5	5
Public Private Partnerships(PPP)	2	2
Improve response	15	15
Extend coverage	7	7
Improve metering	6	6
Quality checks	16	16
Plan efficiently	1	1
No response	11	11

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 Introduction

This Chapter endeavors to discuss the findings of the results obtained from the study. The obtained findings are discussed in line with the framework for formulating operations strategies in Figure 2.4 and the empirical evidence.

5.2 Background characteristics of respondents and households

The total number of household and respondents to whom questionnaires were administered was ninety (90). The background characteristics of respondents such as age indicated that 83% of respondents were above 25 years old, 84% had attended up to secondary or tertiary education level, and 86% had been in their residence for over a year. These characteristics described above gave confidence to the study that the respondents were of the right age, had adequate education and relevant experience in their households to understand the matter that was being researched. The average number of household members in the selected households was 8 which represented 54% of households. The household number characteristic was relevant to understand if the number of people in a household had an effect on the cost of LWSC water and borehole installation and also the frequency of use of the water by households .There were two main sources of water for the households selected that is borehole and piped tap water. 61% of respondents were using borehole water and the rest had piped water. The selected households were in Chalala, Libala and Chelstone Obama.

5.3 Households with boreholes

The data collected in these households was to help establish if there were any competitive advantages that the boreholes and borehole water had over piped water in terms of cost, quality, time and flexibility. Chalala and Chelstone Obama were selected because these are two prominent examples of new residential areas which are yet to be connected by Lusaka Water and Sewerage Company and thus mostly rely on borehole water for household use.

It was realized from respondents that boreholes were quite costly to construct, install and operate. From the survey, it was discovered that 75% of respondents had spent over K10,000 just to drill and install their borehole, and the average cost was K17,425. About 38% of respondents submitted that along the way, their boreholes had broken down and needed repairs. The average cost of K1,819 had been spent by individual households in these instances. 80% of households claimed to be pumping borehole water often for all their water needs and therefore this raised their operating costs due to increased cost of pumping. Looking at the cost incurred in terms of construction, installation and maintenance of individual household boreholes, it would be more convenient, and cost efficient for the residents to be supplied from a single source that is managed and maintained by the water utility company.

It was also observed that in 86% of households, boreholes were constructed less than 10m from the soak away or septic tank. The average distance was determined as 7.6 meters. This was seen as a serious water quality risk as all the sampled boreholes fell short of the 30 meter distance which has been recommended by the World Health Organisation (WHO, 2006). It was then discovered that about 82% of households had no clue about borehole construction regulation or recommendations and had therefore not ensured that such was followed during construction and installation. This was the main reason why the borehole-soak away distances didn't meet the recommended standards. Only 11% of respondents were reported to have carried out water quality tests on their water. In spite of this, only 5% of respondents were sure that a household member had at one point in time suffered from a disease that could have been water related. This however doesn't nullify the dangers that unsafe water poses as some effects can only be realized in the long term.

It was observed that boreholes were very flexible in terms of access and therefore households could get their water whenever they wanted. However, some respondent submitted that in peak dry seasons, drawing water from boreholes can be challenging because the water levels fall too low thus making boreholes unsustainable.

5.4 Households with piped water

The data collected from households with piped water supply from LWSC was also arranged in such a way that it would make it possible to establish the competitive advantage that pipe water

had over borehole supply in terms of quality,cost,flexibility and time. The data was also supposed to help the study justify why it was advantageous for the new residential areas to be piped by the water utility company and what competencies Lusaka Water and Sewerage Company will need to focus on if this is to succeed. Libala area was chosen because it was one of the areas that was observed to be receiving continuous water supply prior to the research and could serve as a benchmark if connection is extended to the uprising residential areas of Lusaka.

From the survey and as illustrated in Figure 4.7 it was discovered that over 60% of respondents thought LWSC water supply services were affordable and they were therefore getting their value for the money. It was observed that value was reflective because the consumers in this area had a readily available service. About 63% of respondents were seen to be spending about K100 – K300 per month. This can indeed be considered as affordable for an average household of 7.

From the finding illustrated in Figure 4.9, it was clear that most respondents (71%) thought that the water supplied by LWSC was of good quality. This was validated by the response that 91% of households had not experienced or suspected any member of their household to have suffered from a disease that they thought was water borne.

In terms of flexibility, Figure 4.11 shows that 91% of respondents from the study area reported to be receiving flexible service from LWSC whenever they needed it, every time of the day or night. This made the consumer have a customized feel towards the water supply.

As shown in Figure 4.12, a little over half of respondents (51%) had LWSC respond to their water related issues at least within 48 hours. However, this competence was biased toward the surveyed area because the customer service center was easily accessible.

Overall, 83% of households for piped water were thought to be generally satisfied with the water supply service that was being rendered. Both sets of respondents, that is those with boreholes and those with piped water submitted and agreed that having a decentralised water supply system in new residential areas was a good idea.

5.5 Physical, Chemical and Microbiological quality of water supplied in the selected residential areas.

Two water samples were taken randomly from each selected household locations, i.e. Chalala, Libala, and Chelstone Obama. These samples were analysed physically, chemically and microbiologically as illustrated in Table 4.7 and Appendix 4 in detail. Special sampling considerations were taken when sampling water from the sources where it was sampled from. All the collected samples were kept in a cooler box that contained ice packs and analysed within 6 hours of collection using prescribed methods such as the membrane filter method, the Atomic Absorption Spectroscopy (AAS), XRF and other physical methods.

All physical parameters for both pipes and borehole water fell within acceptable tolerances as recommended by World Health Organisation (WHO) except turbidity which was relatively higher. All chemical parameters for both piped and borehole water with the exception of Nitrates in Chalala were all within the recommended limits. The borehole water from both Chalala and Chelstone Obama tested positive for high levels of total and feacal coliform bacteria and generally had high turbidity levels. Piped water supplied by LWSC in Libala was void of total and feacal coliforms. The contaminated borehole water found was in line with previous studies done in similar localities. For example, in early 2017, a microbiological assessment of water was done in Libala south which indicated extensive use of contaminated groundwater which might lead to adverse health effect (Nakaonga et al, 2017). Figure 5.1 shows the results that were obtained in the Libala South Borehole Survey. Also, on 7th of June, 2015, an article was published in the Times of Zambia by Charles Simengwa, Stanslous Ngosa, Moffat Chazingwa and Chusa Sichone which indicated that the escalated borehole drilling activities were harming groundwater in Zambia (Times of Zambia, 2015).

In February 2016, Lusaka Water and Sewerage Company issued a borehole alert. The LWSC had a good reason to be concerned because the people threatened by cholera are not just those thought to be drawing contaminated water from shallow wells, but also those in townships and suburbs like Chalala, Kamwala South, Chelstone and Avondale, who rely on boreholes for their water supply. This is because towards the end of 2015, National Water and Sanitation Council (NWASCO) had warned that over 80% of private borehole supplying water to the majority of households in Chalala alone was contaminated with effluent (Times of Zambia, 2016).

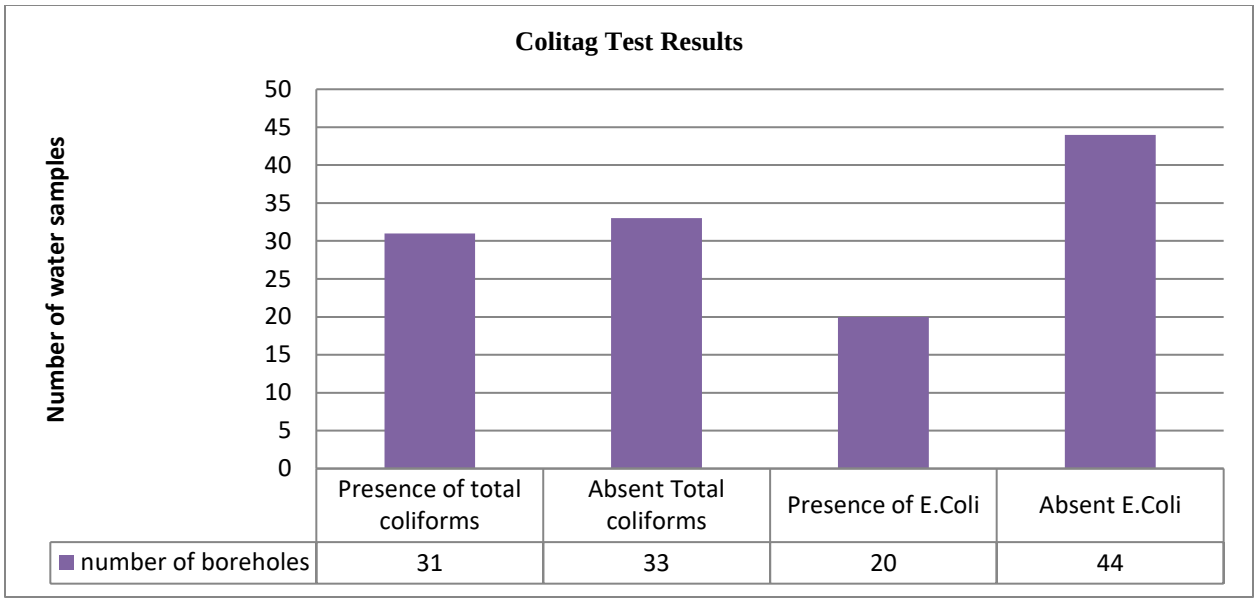

Figure 5. 1: Colitag™ test results of borehole water in Libala South, Lusaka. (Nakaonga eta l, 2017)

5.6 LWSC Situation Analysis.

5.6.1 Institution Framework

With regards to the monitoring of the quality, cost, flexibility and time of service delivery in new residential areas, there is really no clearly documented policy or framework that LWSC follows. However, the regulator, National Water and Sanitation Council (NWASCO) stipulates water service standards that the utility company, in this case, LWSC must comply with as they supply water to the consumers. This is done mostly through Service Level Agreements and Guarantees that the water utility company is required to have by NWASCO so as to guarantee customers with a defined level of service (see Appendix 11). Quality monitoring is done through watch groups which are also set up by the regulator NWASCO. NWASCO also sets the water tariffs for the water service.

The only type of framework that exists is the legislative framework which shows the institutions that are involved in water activities in Zambia. The legislative framework supports the establishment of water utility company.

5.6.2 Operational Core Competencies

The competitive position of an organization is determined by the dimension of Quality, Cost, Flexibility and Time that the organization possesses. The findings of the research showed that LWSC is always meeting the set standards and guidelines for safe drinking water. This was LWSC's highest competency. The Cost of water which is set by the regulator was seen as being generally good for the consumer. However, LWSC considers the cost of water to be too low and not reflective considering how much it costs to produce and distribute. The Flexibility dimension is not good and usually depends on the area where one is. The areas which receive water continuously will always have a flexible feel to the water supply service they receive. It was finally discovered that due to lack of necessary materials, the competence of Time is not met most adequately. This is because the utility company spends most its time looking for materials needed to maintain its old infrastructure that frequently breaks down instead of extending connection to uprising residential areas which are yet to be connected.

5.6.3 Challenges in connecting new residential areas

The main challenge that Lusaka Water and Sewerage Company faces with regards to connecting new residential areas is capacity in terms of water versus the demand of water that is already there. The current demand for water in Lusaka is higher than the production capacity that LWSC has and therefore the water utility company is barely meeting the demand across the district as a whole. LWSC also lacks sufficient operational materials for it operations. This is because there is too much reactive maintenance which is because of the aged infrastructure, some of which is over 40 years old. As a result of this, there is little time to look into new areas. Most of the equipment needed by water utility companies are capital equipment. However, the cost of the infrastructure needed and also infrastructure renewal cannot be financed from prevailing water tariffs. As a result, there does not seem to be enough finances that would enable LWSC to extend its coverage to most of the new residential areas. Based on LWSC data (2010), Unaccounted for water (UfW) (which equals to Losses/Water Production) and the Non- Revenue (NRW) water (Billed Consumption/ Water Production) are very high with calculated rates being 47.5% and 47.2% respectively. This clearly illustrates LWSC minimal investment in proper metering and piping systems. According to NWASCO the performance indicators for UfW are; Good < 20%, Acceptable 20 – 25% and Unacceptable > 25% (Millenium Challenge Corporation, 2011).

5.6.4 Strategies to Mitigate Challenges

To mitigate the various challenges that Lusaka Water and Sewerage Company faces in its endeavor to supply water to the new residential areas of Lusaka, a good number of strategies have been put in place. The main strategy that stands out is the Lusaka Water Supply Investment Master Plan. This plan mostly rides on the investment that was received from the Millennium Challenge Corporation through the government of Zambia. This plan addresses the necessary increase in design capacity, addresses the tailored extension of the distribution networks and the required increase of storage capacity in the network for the various horizons presented within. The investment plan also considers projected improvements regarding non-revenue water, future urban developments, and a balanced scorecard for LWSC (Millenium Challenge Corporation, 2011).

So far under the Millennium Challenge Account networks are being extended to Ndeke and Kwamwena through use of decentralized boreholes. The Kafue bulk project (150m dollar project) is also underway and will bring in an addition of 50000m^3 per day into Lusaka.

Ultimately the objectives of the master plan are to attain, 100% access to safe water by 2035, and 80% access by house connection in 2035 (from the current 35%). Appendix 8 and Appendix 9 illustrates LWSC water supply projections which have fully taken into consideration the population growth.

The other strategies that LWSC has put in place to mitigate the challenges are outlined in LWSC Strategic Plan (2014-2018). Among these strategies, LWSC endeavors to improve efficiencies in the control and repair of leaks to reduce NRW, Develop and implement water safety plan and utilise underground water resource model. It also plans to increase water production from 270,000m^3 to 594,000m^3 per day by constructing new water resources and reduction of water production and transmission losses. Another strategy is to implement the asset management policy which include; Development and implementation of maintenance management policy, implementation of asset renewal policy, disposal policy and carry out condition monitoring. LWSC also plans to reduce energy cost per cubic meter of water produce through the implementation of the Energy management strategy. (LWSC Strategic Plan, 2014-2018)

5.6.5 Borehole Operations and Decentralization Considerations

Over the years, Lusaka Water and Sewerage Company has capitalized on the available groundwater resources and currently operates over 100 boreholes. By 2010, LWSC has 92 boreholes which were providing about 60% of the daily production. These boreholes either feed directly into parts of the distribution system where they are located or serve satellite peri-urban areas. Considerations to decentralize borehole operations are still there as seen in the case of Meanwood Ndeke and Kwamwena. However, the respondent submitted that boreholes were not sustainable in due to high installation and operation costs and changing weather pattern which make them unable to yield water throughout the year and thus are fast becoming unreliable. For example, despite the surveys conducted, the project for Kwamwena had faced challenges in finding the water and this led to increased drilling and construction costs. Therefore, management general direction is water to come from a surface source for example Kafue River. However, this is not to make boreholes obsolete, but they will still be considered useful in places where there is no opportunity or chance to connect using surface water.

5.6.6 Resources needed to connect uprising residential areas

The main resource that will be needed for LWSC to connect the uprising residential areas is the water resource. This is LWSC biggest challenge. If there is no source of water, water cannot be supplied. If a source is established, the other critical resource that will be need is the financial resource. Monetary resources can be obtained from funders and other private stakeholders and partners. The financial resources will enable the water utility company to hire the relevant personnel, design distribution network and acquire construction materials such as pipes, pumps, valves, reservoirs and so on.

5.6.7 Plans for Real Estate Stakeholder Engagement

One of LWSC on going strategies in connecting new residential areas is to work with the private real estate stakeholders. With these strategies in place, real estate providers usually solicit the guidance of LWSC during the construction phase and then hand over the water reticulation system to LWSC to maintain and operate after the housing projects are done. In this way, LSWC's burden for connecting such areas is eased. An example of an area which was developed

by real estate providers and has now been handed over to LWSC in Lusaka is Roma Park in Foxdale.

5.6.8 Room for Subcontracting

LWSC currently has no plans to subcontract for the various stages that consist the water supply process which are production, transmission and distribution. However, the respondent agreed that such an idea could work to bring about efficiency in the water supply systems but had also its own disadvantages. The disadvantage is that if one side slacks, the blame can fall on one party who might not even be the cause of the slack.

5.6.9 Key Competencies to nurture

The competence of Time and Cost were identified as the two main competencies that LWSC should nurture if it has to supply water to uprising residential areas of Lusaka. The time competence can be realized through full implementation of the Asset Management Policy. Asset Management entails LWSC getting to know both their assets and condition of the assets. If the condition of the assets is known, LWSC will know which assets to overhaul or repair through wise investments. Having assets which are in good condition will reduce the time that is spent on reactive maintenance in areas which are already connected and LWSC will thus focus on extending connections to new residential areas yet to be connected.

The cost of the water that LWSC supplies generally affordable for the majority of consumers. However, this is not a real competitive advantage for LWSC because the cost of production of the water is way above the revenue that is realized from water bills. LWSC will need to nurture this competence by making a case with the regulator, NWASCO to balance the price of water. If this is achieved together with the extension of connection to the new areas, LWSC will be able to achieve economies of scale and thus be profitable.

5.6.10 Ways of improving the governance and delivery of water service in the uprising residential areas-Managements View

Governance and service delivery can be improved through the establishment of favorable policies by the government and the sector regulator. Favorable policies will see to it that there is

a firm institutional framework established that will address water supply issues with regards to cost, quality, time and flexibility.

5.7 How LWSC can improve governance and delivery of water services-Households respondents view.

Table 4.8 shows eleven categories of themes that were derived from consumers when they were asked to suggest ways in which they thought governance and delivery of water services would be improved.

The replacement of old leaky taps in various households and the installation of decentralised complementary boreholes were referred to 13 times by the household respondents. The consumers thought that these factors would help in addressing several lacunas that would result in improved service delivery.

Reduction of tariffs was cited 12 times as a way of LWSC improving its governance. However, this can be tricky to accomplish because, it has already been illustrated and analysed in Figure 4.7 that about 60% of respondents from the already piped study cite found the services to be affordable. This might not be the case in other areas as observed by the study and this response can be considered biased to the researched area.

Increased notification in cases of water interruption due to maintenance and other factors was another prominent theme that was referred to at least 12 times. Respondents submitted that they are rarely informed of times when to expect erratic supply and this affected the household operations. This therefore alludes to the fact that LWSC lacked the necessary consumer engagement which it needs to seek when dealing with the water related issues. Consumer engagement can be done through various awareness programs and other research surveys that would involve the engagement of consumers.

Respondents also indicated that LWSC can improve its governance and water service delivery by simply improving it customer service. This theme was referred to 5 times. Respondents thought that the customer service that LWSC provides was not up to standard. This could be because of few customer service centers that are available or simply the lack of properly trained customer service agents who lack certain crucial customer service skills. LWSC also did not have a toll-

free line that customers can use to easily submit complaints. Therefore, it is imperative that LWSC addresses these customer service concerns for it to improve its services.

Public-Private Partnerships (PPP) was also suggested as a measure that LWSC needs to take in order to improve its governance and water service delivery. This means that LWSC has to engage and identify the right players in the private sector especially financial institutions, who it can work with under cost reflective on take and off take agreements to finance a number of its pending projects.

Improving the response time towards water related issues would go a long way in making sure the LWSC improved its service delivery. This theme was referred to 15 times by respondents. Improvement in response will have to do with LWSC refining its maintenance schedules so that it is able to sort out consumer complaints immediately they arise. Proactive monitoring of households to see if there are underlying water related issues would also help in improving the response time and ultimately service delivery.

Residents expressed the thought that the control of water services would be improved if LWSC can be able to extend its services to the newer uprising residential areas. This theme was referred to 7 times and residents were believed to have noticed the fast rate at which the city is growing. Some were knowledgeable enough to see the adverse effect that can be realized on the quality of groundwater if every developed house should put up their own borehole in the future. However, for extension to be possible there is need for LWSC to increase its water generation capacity and this can only be done through a clearly laid down capacity strategy.

Respondents also saw the optimization of the metering systems as one of the ways of improving the service provided by LWSC. The respondents mentioned this theme 6 times. The reason for this response was because they sometimes thought that the bills received at the end of the month were most of the times inflated and unrealistic. This had made these consumers to be suspicious of the metering systems that LWSC had. Some went as far as recommending the removal of their prepaid and reverting back to the meter boxes. Therefore, it is imperative that LWSC continues to look into the metering issue as their revenues solely depends on this.

The final main theme referred to was that of improved quality checks. This was mentioned 16 times by the respondents. They were adamant that frequently testing household water for quality,

monitoring the levels of chlorine put and ensuring overall that there was clean water supplied to the residential areas would enable LWSC to be better in its service delivery.

However, for all these suggestions to be fully implemented, it is important that LWSC deliberately continues to monitor its systems for the purposes of planning effectively.

5.8 Feasibility and acceptability of LWSC putting up decentralised water supply systems.

The feasibility of LWSC putting up a decentralised borehole reticulation system in the uprising residential areas of Lusaka was analysed with reference to the following;

- Operations Requirements
- Market Requirements
- Technological Requirements
- Legal Requirements
- Economic Requirements(reference)

5.8.1 Operations Requirements

Operations requirements simply have to do with material resources needed to complete the project such as labour, readily available ground water, pipes, valves etc. LWSC labour force already consists of qualified engineers and technicians capable of designing the needed networks and also making the necessary installations. Ground water resource is readily available as illustrated by the already numerous boreholes erected in the study sites. Resources such as pipes, valves are available on the Zambia market and can easily be sourced.

5.8.2 Market Requirements

The markets which are the uprising residential areas are growing at an alarming rate and already sufficient households to which LWSC would be able to supply water. Some of these areas, for example Chalala have more than 5000 households and this in itself would render market requirements for the decentralisation project feasible.

5.8.3 Technological Requirements

Over the years, LWSC has been exposed to the relevant technology that is applicable to the water sector such as standardised pumping technology and water point designs. Some of this

technology is already being applied as seen in the case of Meanwood Ndeke and Kwamwena and new woodlands extension.

5.8.4 Legal Requirements

LWSC has clearly laid out legal responsibilities and these mostly include the provision of water and sanitation services in areas of jurisdiction of Lusaka City and to exercise control over water sources. The legal framework that protects LWSC consists of the Water Supply and Sanitation Act, the Company Act and the local government Act as illustrated in Figure 1.4.

5.8.5 Economic Requirements

Economic and financial requirements that LWSC needs are and can be made available. This can be seen from number of projects that LWSC is already undertaking with the help of various financiers and donors. For example, in late 2017, the European Investment Bank (EIB) signed a major loan deal worth 102.5 million Euros with Zambia to invest in the overhaul and expansion of sanitation infrastructure in the country's capital (www.out-law.com). The Millennium Challenge Corporation (MCC) has also been partnering with the LWSC since 2013 to improve water supply systems in Lusaka and they are an example of how willing donors and financiers are willing to work with LWSC. This makes extension and decentralisation of water supply system in new residential areas feasible.

5.9 Acceptability of Decentralisation

Most respondents from the households under investigation agreed that decentralization of water supply systems was a good idea. This is illustrated in Figure 4.14.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions in relation to objectives, literature and findings presented in the earlier chapters. The chapter further makes recommendations on what is needed to be done for LWSC to improve its services and extend connections to the unconnected uprising residential areas of Lusaka district.

6.2 Conclusions

There is no clearly documented policy within the institution framework with regards to the monitoring of water supplied in new residential areas in terms of quality, cost, flexibility and time. However, service quality is continuously monitored through the regulator NWASCO and as a result LWSC is always meeting the prescribed water quality standards. This has made Water Quality to be LWSC's main operational core competence. The quality competence is closely followed by the cost competence which is thought to be generally good for the consumer. Unfortunately, the current tariffs are set by the regulator NWASCO and don't reflect the cost of production. This barely gives an advantage on the side of the water utility company.

The main challenge that LWSC faces in terms of connecting new areas is capacity versus the demand of water that is already there. Population growth rate is obvious one of the main reasons for the rise in demand. The worn-out aged infrastructure which is estimated to be over 40 years old is also another challenge that LWSC faces. Since the infrastructure is old, the frequency of break downs is high which in turn results in high reactive maintenance time. This take away the value time needed to focus on extending water service coverage to new areas.

The investigation of the physical, chemical and microbiological quality of water tested in the selected residential area of Lusaka revealed that piped water was more reliable than water that was being accessed from boreholes in the new residential areas. Piped water supplied by LWSC was found to have almost all physical, chemical, and microbiological parameters falling within the acceptable limits as stipulated by World Health Organisation (WHO). On the other side,

borehole water sampled in Chalala and Chelstone Obama showed that it was contaminated with very high level of total coliform and feacal coliform bacteria which posed a health risk. Majority of respondents in residents with boreholes also serious lack of knowledge with regards to borehole construction requirements and as a result majority of households did not follow the standard between septic tank and the borehole. Therefore, elevated levels of feacal coliforms were present in the borehole water that was sampled. All these findings illustrated the need for LWSC to quickly connect the new residential areas to the main water reticulation system and hence provide safe drinking water.

Putting up of a decentralised water supply network in Lusaka City's new residential areas was determined as feasible. It was realized that the residents were spending considerable sums of money on construction and installation of boreholes. Adding the repair costs for those households who have had their pumps break down before, and the daily operating costs in terms of power usage, the need for a reliable piped network supplying affordable safe drinking water could not be over-emphasized. An average household spent about K17,425 just to construct and install a borehole. Those who had encountered pump breakdown spent an average cost of K1, 819 to repair the pump.

The residents accepted the idea of Lusaka water putting up a decentralised water supply system using boreholes even though LWSC had indicated that it is trying shift direction from boreholes to surface water.

6.3 Recommendations

In line with the findings and conclusions made above, the following are the recommendations to LWSC;

1. Initiate capacity strategy by fully implementing the Asset Management Policy to determine which infrastructure to replace with new ones.
2. Configure resources and processes to focus on speedy and timely delivery of services.
3. Involve community and private investors in endeavors to improve and extend coverage to new residential areas.
4. Decentralize water supply to new residential areas and sensitize residents on benefits of having a decentralized reticulation system for cheaper and safer drinking water.

5. Consider subcontracting the stages of water production and transmission in order to increase efficiency

6. Management should draft properly document operations strategies and make them known to the employees (see Appendix 10).

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APPENDICES

Appendix 1: Household Questionnaire administered to the selected households.

Questionnaire No.: **__ __**

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF AGRICULTURAL ENGINEERING

Assessing Lusaka Water and Sewerage Company's (LWSC) operations strategies in its endeavor to provide affordable water services in Lusaka's new residential areas

CONFIDENTIALITY AND CONSENT

Dear Respondent,
Good morning/afternoon. Thank you for taking time off to respond to this questionnaire. My name is_____, I am a member of a team of people from the University of Zambia conducting a study on levels of compliance to borehole regulation requirements amongst residents in selected residential areas in Lusaka district. The purpose of my visit is to ask you some questions related to the matter.

Your name or household will not be written on this questionnaire, and will never be used in connection with any of the information you tell me. This research is purely for academic purposes only. I would greatly appreciate your help in responding to the questions.

Name _____ Signature _____Date_____

01: Location: Libala *1*
Chelstone Obama *2*
Chalala *3*

02: Results code: Completed 1
Partially completed 2

03: Date of Interview: ____/____/2017

PART 1: BACKGROUND CHARACTERISTICS OF RESPONDENT

QID	Question	Response Categories	Skip to
Q1	Sex of respondent	Male 1 Female 2	
Q2	How old are you?	Age __ __	
Q3	What level of education have you completed?	Primary 1 Secondary 2 Tertiary 3 No education 4 No response 8 Don't know 9	

PART 2: HOUSEHOLD CHARACTERISTICS

QID	Question	Response Categories	Skip to
Q4	How long have you stayed in your current home?	0 – 1 years 1 1 – 2 years 2 2 – 3 years 3 3 – 4 years 4 4 – 5 years 5 5 years and above 6 No response 8 Don't know 9	
Q5	How many people currently live in your household?		
Q6	What is your source of water?	Borehole/ Well 1 Tap/Piped water 2 Bottled Water 3 No response 8 Don't know 9 Other (specify) ……	 **→Q23** **→Q17** **→Q17** **→Q17**

PART 3: HOUSEHOLDS WITH BOREHOLES

Q7	What was the total cost of drilling and installing the borehole unit at this residence?		
Q8	Do you know any of the regulations or guidelines required for installing a borehole at any house?	Yes 1 No 2 No response 8 Don't know 9	 **→Q11** **→Q11** **→Q11**
Q9	Which regulations/guidelines do you know?	>	

		> > > >	
Q10	Where these regulations followed when installing the borehole at this residence?	Yes 1 No 2 No response 8 Don't know 9	
Q11	What do you use water from the borehole for? ***(tick all that apply)***	Drinking [ ] Bathing [ ] Cooking [ ] Washing [ ] Gardening [ ] Other (specify) …….	
Q12	How often do you pump water from the borehole?	Not often 1 Often 2 Very often 3	
Q13	Has your borehole pump ever broken down or needed repairs?	Yes 1 No 2 No response 8 Don't know 9	 **→Q16** **→Q16** **→Q16**
Q14	Did you have it repaired?	Yes 1 No 2 No response 8 Don't know 9	 **→Q16** **→Q16** **→Q16**
Q15	How much was the cost of repairing the borehole pump?		
Q16	What is the distance between location of borehole pump and soak away/septic tank? ***(you can physically check)***		
Q17	Has your water ever been tested for quality?	Yes 1 No 2 No response 8 Don't know 9	 **→Q19** **→Q19** **→Q19**
Q18	Where was the water tasted for quality?		
Q19	Has anybody in your household suffered from a disease that you might have suspected to be waterborne?	Yes 1 No 2 No response 8 Don't know 9	 **→Q21** **→Q21** **→Q21**

Q20	What was the disease?		
Q21	Do you think it is a good idea for LWSCo to sink boreholes that would supply water to a number of households in this area?	Yes 1 No 2 No response 8 Don't know 9	
Q22	How can LWSC improve governance and delivery of water services?		

END – HERE. Thank you

PART 4: HOUSEHOLDS WITH PIPED WATER

QID	Question	Response Categories	Skip to
Q23	How affordable is the water supplied by LWSC?	Very affordable 1 Affordable 2 Barely affordable 3 Not affordable 4 No response 8 Don't know 9	 **→Q25** **→Q25**
Q24	How much do you pay for the water per month?		
Q25	Do you think piped water from LWSC is of good quality?	Yes 1 No 2 No response 8 Don't know 9	
Q26	Has anybody in your household suffered from a disease that you might have suspected to be waterborne?	Yes 1 No 2 No response 8 Don't know 9	 **→Q28** **→Q28** **→Q28**
Q27	What was the disease?		
Q28	Does LWSC supply you with water every time of the day or night?	Yes 1 No 2 No response 8 Don't know 9	
Q29	How much time does it take LWSC to respond to water related problems when you inform them?	Within 12hrs 1 Within 24hrs 2 Within 48hrs 3 Within 1 week 4 Within 2 weeks 5 No response 8 Don't know 9	
Q30	How satisfied are you with the water services	Very satisfied 1	

	supplied by LWSC?	Satisfied 2 Barely satisfied 3 Not satisfied 4 No response 8 Don't know 9	
Q31	Do you think it is a good idea for LWSC to sink boreholes that would supply water to a number of households in new residential areas?	Yes 1 No 2 No response 8 Don't know 9	
Q32	How can LWSC improve governance and delivery of water services?		

Thank you for taking time to respond to my questions

Appendix 2: Interview guide for LWSC Key Informant (Management)

INTERVIEW GUIDE – MANAGEMENT

1. What position do you have in this company?

2. How long have you served in this position?

3. What is the highest level of education you acquired?

4. Is there any institutional framework for water quality monitoring? **(If *NO* or *NOT AWARE OF ANY*, SKIP to Q6)**

5. What institutional framework has LWSCo put in place to monitor the quality of water in the households?

6. Operational wise, what challenges is LWSCo facing in connecting new residential areas to the main water supply systems?

7. Is there any strategy in place to address the challenges being faced? **(If *YES*, what strategy?)**

8. What is LWSCo doing to make sure that you are proactive and not reactive to the rapid rise of new residential?

9. Does the population growth rate affect the way you plan as an organisation?

10. What do you think are LWSCo's operational core competencies? *(Quality, flexibility, cost, time).*

11. Are there boreholes that are currently being operated by LWSCo in the province? **(If *YES*, how many are they?)**

12. Are there any considerations by LWSC to put up a decentralized (boreholes) water supply system in new residential areas? **(if *YES* how much progress towards decentralization and the SKIP to Q14)**

13. If **No** to question 12. Do you think it can be a good idea for LWSCo to put up a decentralized (boreholes) water supply systems in new residential areas that can be able to supply a number of households?

14. What resources will be needed for the decentralization process to be completed?

15. Where will these resources come from?

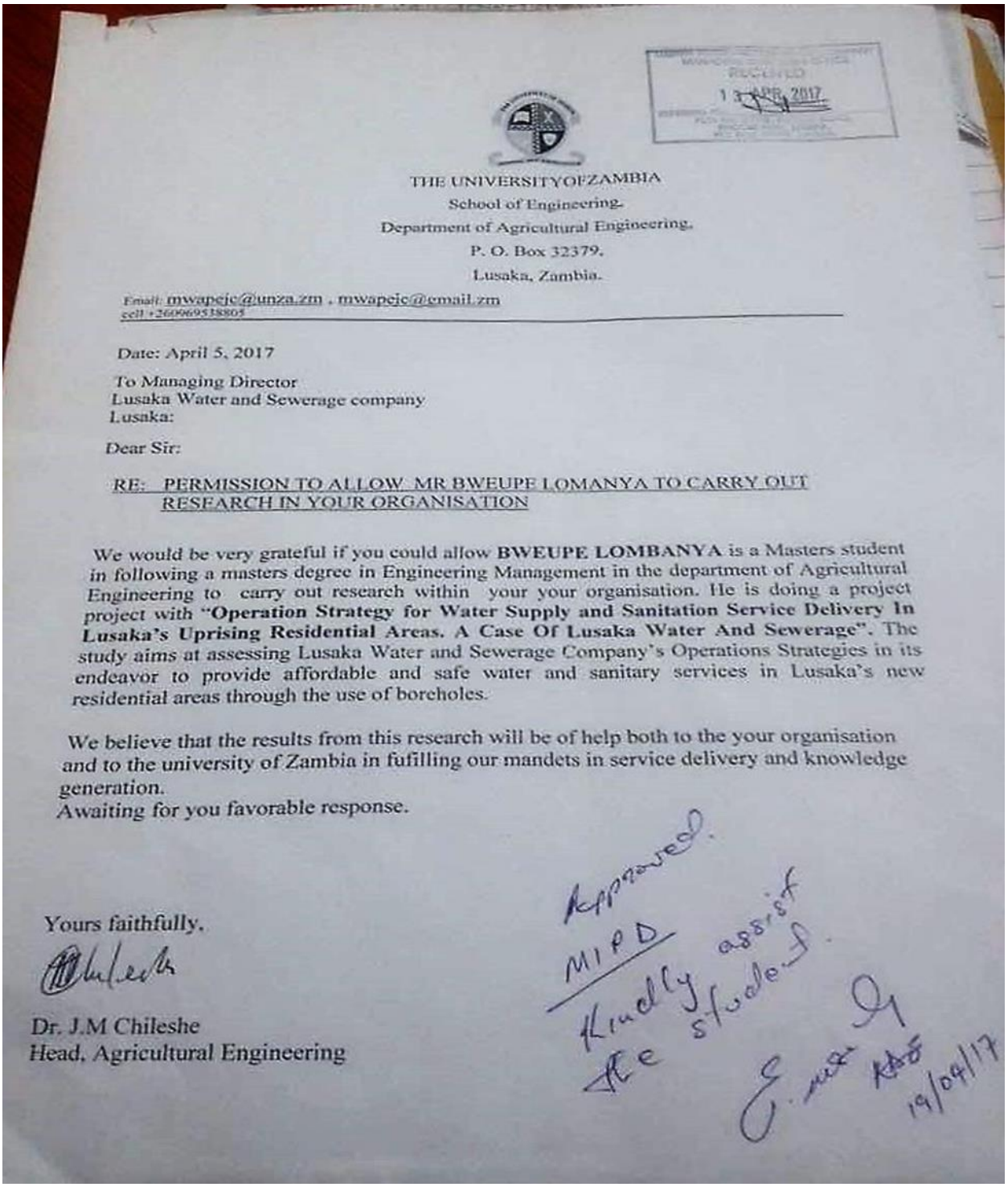
16. How will LWSCo work with real estate stakeholders?

17. Is there or will there be any room for subcontracting for the various stages in the water supply process?

18. What do you think are the key competencies*(Quality, flexibility, cost, time)*that operations will need to focus on most, for the decentralization process to be successfully undertaken?

19. What are some of the ways of improving the governance and delivery of water services in the new residential areas?

Appendix 3: Introductory Letter



THE UNIVERSITYOFZAMBIA
School of Engineering
Department of Agricultural Engineering,
P. O. Box 32379,
Lusaka, Zambia.

Email: mwapejc@unza.zm , mwapejc@email.zm
cell: +260969538805

Date: April 5, 2017

To Managing Director
Lusaka Water and Sewerage company
Lusaka:

Dear Sir:

RE: PERMISSION TO ALLOW MR BWEUPE LOMANYA TO CARRY OUT RESEARCH IN YOUR ORGANISATION

We would be very grateful if you could allow **BWEUPE LOMBANYA** is a Masters student in following a masters degree in Engineering Management in the department of Agricultural Engineering to carry out research within your your organisation. He is doing a project project with **"Operation Strategy for Water Supply and Sanitation Service Delivery In Lusaka's Uprising Residential Areas. A Case Of Lusaka Water And Sewerage"**. The study aims at assessing Lusaka Water and Sewerage Company's Operations Strategies in its endeavor to provide affordable and safe water and sanitary services in Lusaka's new residential areas through the use of borcholes.

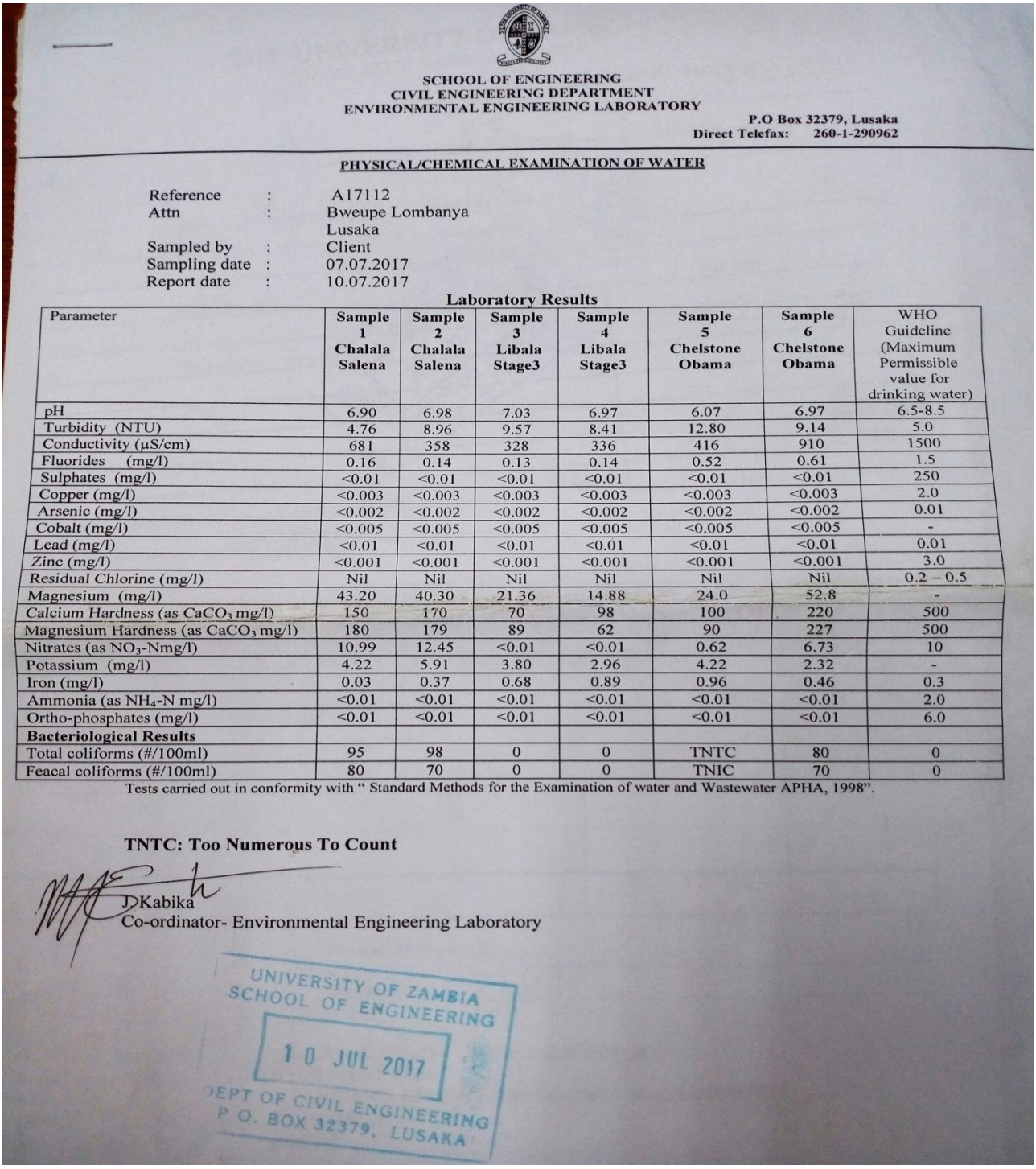
We believe that the results from this research will be of help both to the your organisation and to the university of Zambia in fufilling our mandets in service delivery and knowledge generation.
Awaiting for you favorable response.

Yours faithfully,

Dr. J.M Chileshe
Head, Agricultural Engineering

Approved.
MIPD
Kindly assist the student.
19/04/17

Appendix 4: Original results for the Physical, Chemical and Microbiological examinations of water.



SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING LABORATORY

P.O Box 32379, Lusaka
Direct Telefax: 260-1-290962

PHYSICAL/CHEMICAL EXAMINATION OF WATER

Reference : A17112
Attn : Bweupe Lombanya
Lusaka
Sampled by : Client
Sampling date : 07.07.2017
Report date : 10.07.2017

Laboratory Results

Parameter	Sample 1 Chalala Salena	Sample 2 Chalala Salena	Sample 3 Libala Stage3	Sample 4 Libala Stage3	Sample 5 Chelstone Obama	Sample 6 Chelstone Obama	WHO Guideline (Maximum Permissible value for drinking water)
pH	6.90	6.98	7.03	6.97	6.07	6.97	6.5-8.5
Turbidity (NTU)	4.76	8.96	9.57	8.41	12.80	9.14	5.0
Conductivity (µS/cm)	681	358	328	336	416	910	1500
Fluorides (mg/l)	0.16	0.14	0.13	0.14	0.52	0.61	1.5
Sulphates (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	250
Copper (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	2.0
Arsenic (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01
Cobalt (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-
Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Zinc (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.0
Residual Chlorine (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	0.2 – 0.5
Magnesium (mg/l)	43.20	40.30	21.36	14.88	24.0	52.8	-
Calcium Hardness (as $CaCO_3$ mg/l)	150	170	70	98	100	220	500
Magnesium Hardness (as $CaCO_3$ mg/l)	180	179	89	62	90	227	500
Nitrates (as NO_3-Nmg/l)	10.99	12.45	<0.01	<0.01	0.62	6.73	10
Potassium (mg/l)	4.22	5.91	3.80	2.96	4.22	2.32	-
Iron (mg/l)	0.03	0.37	0.68	0.89	0.96	0.46	0.3
Ammonia (as NH_4-N mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2.0
Ortho-phosphates (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	6.0
Bacteriological Results							
Total coliforms (#/100ml)	95	98	0	0	TNTC	80	0
Feacal coliforms (#/100ml)	80	70	0	0	TNIC	70	0

Tests carried out in conformity with " Standard Methods for the Examination of water and Wastewater APHA, 1998".

TNTC: Too Numerous To Count

J.Kabika
Co-ordinator- Environmental Engineering Laboratory

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
10 JUL 2017
DEPT OF CIVIL ENGINEERING
P O. BOX 32379, LUSAKA

Appendix 5: Criteria firms can use to focus their operations

	Focus Criteria	**Ideal operations resource conditions**	**Ideal market requirement conditions**
Operations segmentation based on market criteria.	Performance objectives Cluster products/services by market requirements	Products and services with similar market requirements have similar processing requirements	Market segmentation is based clearly on customer requirements
	Product/service specification Limit number of products/services in each part of the operation	Similar products and services require similar technologies, skills and processes	Products and services are targeted on specific market segments
	Geography Cluster products/services by the geographic market they serve	The geographic area where products and services are created has a significant impact on operations performance	Market segmentation can be based on geographic regions
	Variety Separately cluster high-variety products/services and low-variety products/services together	The nature of technology, skills and processes is primarily determined by the variety with which products/services are created	Market segmentation can be based on the degree of product/service choice required by customers
	Volume Separately cluster high-volume products/services and low-volume products/services together	The nature of technology, skills and processes is primarily determined by the volume at which products/services are created	Market segmentation can be summarised as 'mass markets' versus more 'specialised markets'
Operations segmentation based on resource criteria	Process requirements Cluster products/services with similar process requirements together	The process requirements (types of technology, skills, knowledge, etc.) of products/services can be clearly distinguished	Products and services with similar processing requirements are targeted on specific market segments

Source: (Slack,N and Lewis,M, 2015)

Appendix 6: Lusaka water balance, October 2010

<table>
<tr><td rowspan="6">Water Production

6,926,629m3</td><td rowspan="3">Authorized Consumption

3,660,636m3</td><td>Billed Authorized Consumption

3,637,863m3</td><td>Billed Metered Consumption</td><td>2,619,261m3</td><td rowspan="2">Revenue Water

3,637,863m3</td></tr>
<tr><td></td><td>Billed Un-metered Consumption</td><td>1,018,602m 3</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption

22,773m3</td><td>Unbilled Metered Consumption</td><td>22,773m3
(LWSC facilities)</td><td rowspan="3">Non Revenue Water

3,288,766m3</td></tr>
<tr><td>Unbilled Un-metered Consumption</td><td>0m 3
(zero billed)</td></tr>
<tr><td rowspan="3">Losses
3,265,993m 3</td><td>Apparent Losses

m3</td><td>Unauthorized Consumption</td><td rowspan="3"></td></tr>
<tr><td></td><td>Customer Metering/Billing Inaccuracies</td></tr>
<tr><td>Real Losses

m3</td><td>Leakage on Transmissionand/or Distribution Mains

Leakage and Overflows at Utility's Storage Tanks

Leakage on Service Connections up to point of customer metering</td></tr>
</table>

Source: LWSC, 2010

Appendix 7: Some old assets

Figure A1: Aged pipes

Figure A2: Old Lusaka water works

Appendix 8: Lusaka population projections and water demands, upgrades and extension programmes (Greater Lusaka)

		2010	2015	2020	2025	2030	2035
POPULATION							
LUSAKA DISTRICT	AAGR 2.82%	1,742,979	2,213,962	2,812,208	3,260,112	3,779,367	4,381,324
Kafue		42,071	50,000	100,000	137,840	190,000	261,897
Chongwe		26,740	50,000	100,000	126,491	160,000	202,386
Chibombo		17,788	30,000	30,000	45,826	70,000	106,927
GREATER LUSAKA POPULATION		1,830,000	2,340,000	3,040,000	3,570,000	4,200,000	4,950,000
DEMAND							
DEMAND(m^3/d)		379,552	472,463	594,155	698,788	810,359	936,896
DEMAND(m^3/d) Incl. NRW		730,100	629,951	742,694	873,485	1,012,949	1,102,231

Source: (Millenium Challenge Corporation, 2011)

Appendix 9: Upgrades and Extension Projections

Year	From Groundwater	From Kafue River	Total Production	Remarks
2010	130,000	95,000	225,000	existing
2011	145,000	110,000	255,000	10 boreholes(15,000m^3/d)-drilled under WB
2015	145,000	110,000	255,000	
2015	180,000	110,000	290,000	+25 boreholes(35,000m^3/d)
2015	180,000	480,000	660,000	Upgrade existing to 160,000, add 320,000M/d
2020	180,000	480,000	660,000	
2020	180,000	700,000	880,000	Add 220,000M/d
2025	180,000	700,000	880,000	
2025	180,000	920,000	1,100,000	Add 220,000M/d
2035	180,000	920,000	1,100,000	

Source: (Millenium Challenge Corporation, 2011).

Appendix 10: Model for formulating Operation Strategies

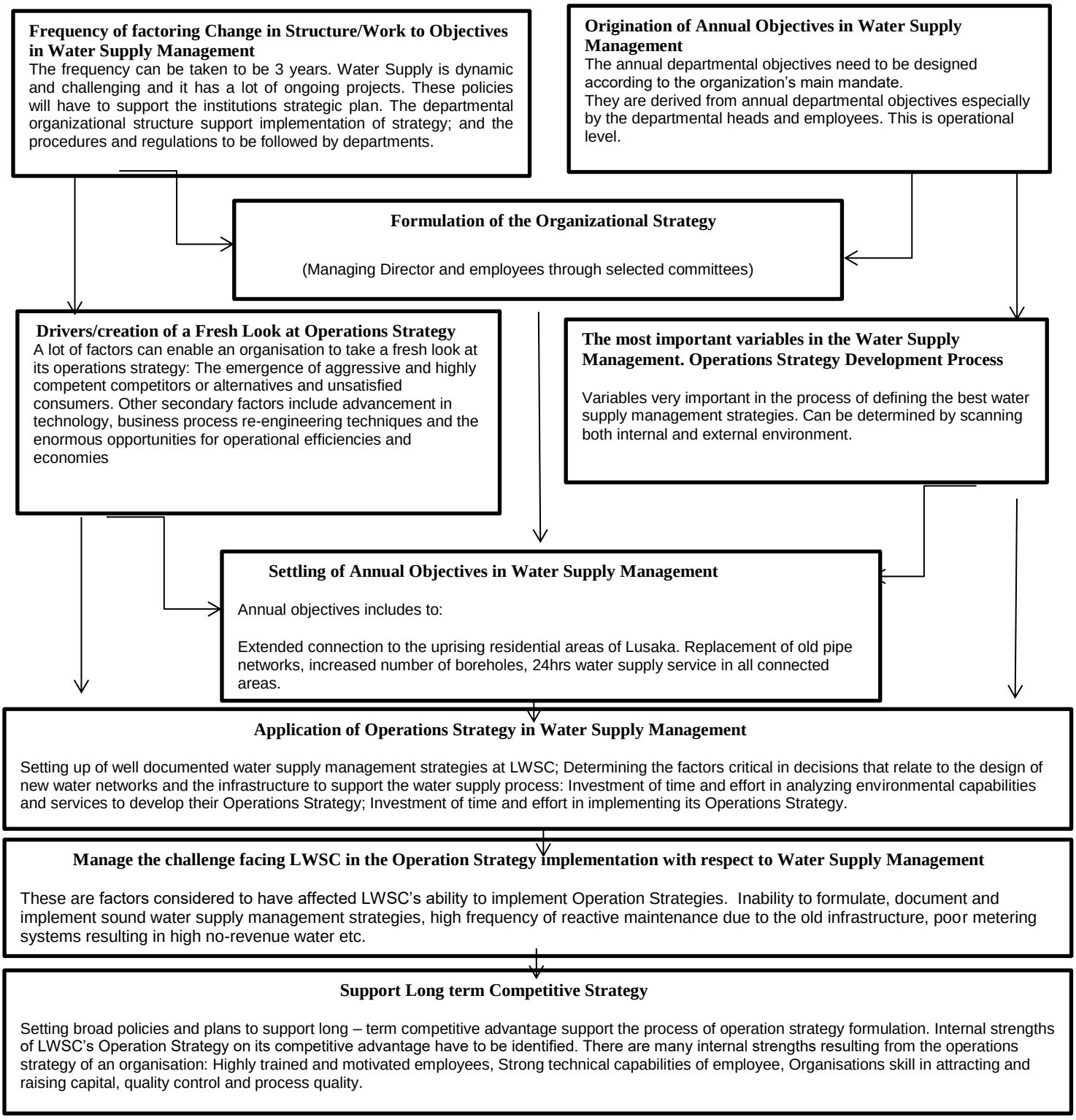


Figure 9: Formulating and documenting Operation Strategies Water Supply Management. Adopted from (Magutu, et al., 2010)

Appendix 11: LWSC Service Level Guarantee (2015-2018)

	SERVICE INDICATOR	PRIMARY INDICATOR	SERVICE LEVEL
SI1	**COVERAGE OF SERVICE AREA**	% of population served with drinking water	88%
SI2	**DRINKING WATER QUALITY**	a. No. of tests carried out (bacteriological and residue chlorine)	According to NWASCO water quality guideline
		b. % of results meeting the standard	95%
SI3	**SERVICE HOURS**	a. average daily water supply duration at connection	22 hours
		b. average daily water supply duration at public distribution system	12 hours
		c. Office hours and pay point per week.	40 hours
SI4	**BILLING FOR SERVICES**	a. frequency of billing customers	Once per month
		b. frequency of customer meter reading	Once per month
		c. payment period after bill delivered	2 weeks
		d. % metering	75%
SI5	**CLIENT CONTACT**	a. Response time to written complaints	5 working days
		b. a.Response time for new connection	10 working days
		c. Response time for meter installation request	10 working days
		d. Response time for meter testing	10 working days
		e. Waiting time to pay bill or file complaint	15 minutes
		f. Telephone contact holding time	5 minutes
SI6	**INTERUPTION OF WATER SUPPLY AND BLOCKAGE OF SEWER**	Water - a. % connected property subjected to unannounced supply interruption for 20 – 36 hours	< 15%
		b. 36 – 48 hours	< 5%
		c. above 48	< 3%
		Sewer - c. % connected property subjected to sewer blockage 20 – 36 hours	< 10%
		d. 36 – 48 hours	< 8%
		f. more than 48 hours	< 3%
SI7	**PRESSURE IN THE NETWORK FOR WATER SUPPLY**	Connection with flow rate of less than 7 litres / minute	< 5% of connections in particular service area
SI8	**UNJUSTIFIED DISCONNECTION**	% of connections subjected to unjustified disconnection in a year	< 0.2%
SI9	**SEWER FLOODING**	% of connections subjected to sewer flooding	< 0.3% of connections in particular service area
SI10	**QUALITY OF DISCHARGED SEWER**	a. No of tests carried out (bacteriological and chemical)	According to ZEMA licence conditions
		b. % of results meeting ZEMA standard	40% for bacteriological and 60% for Chemical

Source: NWASCO